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ERRATA

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Page 26, line 34. for "pubescenti" read "pubescentia"
Page 27, line 32: for "glabrescentes" read "glabrescentia"
Page 28, line 14. for "stellato-villosis" read "stellato-villosa"
Page 28, line 31: for "spuberulo" read "puberulo"
Page 28, line 32: for "atro-purpuea" read "atro-purpurea"
Page 29, line 40. for "infunibuliformi" read "infundibuliformi."
Page 30, line 32: for "subcicinnatis" read "subcincinnatis"
Page 32, line 21: for "tenuibius" read "tenuibus"
Page 33, line 45: for "viridiis" read "viridis"
Page 34, line 7: for "tomentosinusculis" read "tomentosiusculis."
Page 37, line 23 for "Miers," read "Miers'."
Page 175, line 20: delete period after "Sierra" and read "Sierra Tarahumara"
Page 243, line 1: for "Cyanodon" read "Cynodon"
Page 244, line 46. for "Cyanodon" read "Cynodon"
Page 245, line 40: for "Cyanodon" read "Cynodon."
Page 379, line 25: for "three" read "four"
Page 381, line 26: for "for" read "by."
Page 407, legend of fig 2: for "fomations" read "formations"
Page 423, line 29: for "fluxuous" read "flexuous"
Page 444, line 36: for "Schlauche" read "Schläuche."
Page 464, equation (19): for $N_1 = \Sigma P_{rs}\, e^{(r\lambda_1+s\lambda_2)}$ read $N_1 = \Sigma Q_{rs}\, e^{(r\lambda_1+s\lambda_2)}$ and for $N_2 = \Sigma Q_{rs}\, e^{(r\lambda_1+s\lambda_2)}$ read $n = \Sigma P_{rs}\, e^{(r\lambda_1+s\lambda_2)}$
Page 465, in the table of constants: for $P_{11} = 1706.5$ read $P_{11} = -1706.5$ and for $P_{30} = +491.3$ read $P_{30} = +4931.83$

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PALEONTOLOGY.—*The larger Foraminifera of the Talara shale of northwestern Peru.*[1] WILLARD BERRY, Ohio State University. (Communicated by EDWARD W. BERRY.)

In 1928 I described the smaller Foraminifera of the middle Lobitos shales of northwestern Peru.[2] In the same year this formation was named Saman shales by Iddings and Olsson.[3] Again in 1930 Olsson changed the name from Saman to Talara shale[4] and correlated it with the Bartonian as I did in 1928.

In my discussion of the smaller Foraminifera I mention the occurrence of *Lepidocyclina*- and *Operculina*-bearing grits or sandstone about 958 feet above the base of the Talara shales (Saman shales). These grits which are only several feet thick are yellow-brown calcareous sandstones with subangular grains up to 1.5 mm. in diameter. These grains are mostly clear quartz with occasional dark ferruginous grains, apparently limonite What heavy minerals may be present is unknown as no separation has been made These grits are thin bedded and tend to weather to light-colored sand. The beds are very sparsely fossiliferous and the described forms were obtained by prolonged and careful collecting along the strike of the rocks.

The faunule consists of seven species of *Lepidocyclina* and three species of *Operculina*. In this faunule the species of *Lepidocyclina* do

[1] Received October 31, 1931 Work carried out under a grant-in-aid, National Research Council.

[2] Eclogae Geol Helvetiae 21 (2). 390-405 1928

[3] Iddings and Olsson *The geology of northwest Peru* Bull Am Asso Pet Geol. 12 (1)· 1928

[4] A. A. Olsson. *Eocene Mollusca* Bull. Am Paleon 17 (62) 1930

not seem to be closely related to any described forms with the exception of the one species of the subgenus *Helicolepidina* which is very close to *Lepidocyclina (Helicolepidina) spiralis* Tobler from the Priabonian of San Fernando, Trinidad, and Río San Pedro, Venezuela. There is apparently no relation between these forms and the small fauna from the basal portion of the same formation (Saman conglomerate) as described from the Atascadero limestone exposed about 22 miles northeast of this locality. There is a slight similarity between these forms and the as yet undescribed forms from the Talara sandstones (Saman sandstones) collected north of Lagunitos. The similarity between this faunule and the fauna of the Verdun grits (which Olsson now refers to the Eocene) lies in the marked absence of microspheric forms. None have been found in this collection and only about 4 per cent in the Verdun fauna.

The *Operculina* on the other hand bear a closer relation to those of the Atascadero forms, as one is clearly a variety of *Operculina atascaderensis* W. Berry, described from the Atascadero limestone. The other two are new to science.

The exact conditions under which this thin bed of sandstone was laid down are indefinite. Apparently it is a local feature as it is not found everywhere that the Talara shales are exposed. From the coarse subangular character of the sand grains and the lack of microspheric forms sedimentation must have been very rapid The forms are all thought to be typical of shallow, warm, or tropical waters and the shales both below and above the bed contain forms characteristic of deeper and cooler waters From what direction these coarse sediments were washed into the sea is undecided due to the limited extent of the bed. From general appearance it is quite like the matrix of the Verdun grits which are supposed to have come from the southwest. It is quite apparent, however, that during the deposition of the Talara shales there was a period of fairly sudden rise and then sudden deepening of the sea in this region as the shales do not grade into the sands or the sands grade into the shales, the boundaries being very clearly marked. Another possibility is that for some reason the run-off was especially rapid at this point for a short time and much sand was washed into the sea. It is entirely possible that somewhere along the then existing shore the forms from the basal portion of the formation were developing and that they gave rise to this endemic faunule which is to be described. The places where the evolution was going on have either been destroyed by subsequent erosion before the sandstone was deposited or else have not yet been discovered.

Genus LEPIDOCYCLINA.

Subgenus LEPIDOCYCLINA SS

Lepidocyclina samanica W Berry n sp

Figure 10

Test discoidal, equilateral, small, thin, 2 4 mm in diameter, 0 75 mm thick, ratio of diameter to thickness 3 3 1 Test thins more or less evenly from the center to the periphery, with no flange Surface papillated, small and fairly evenly spaced Pillars polygonal in shape and 83 5 microns in diameter at the surface The lateral chambers at the surface are 116 9 microns in diameter with walls 16 7 microns thick

The nucleoconch is composed of two subequal chambers separated by a thin straight wall The width of the nucleoconch is 218 4 microns and the length is 312 microns, the ratio of the length to the width is 1 4 1, with walls 35.1 microns thick The equatorial chambers are arcuate and are arranged in circles; these chambers are 35 1 microns in radial diameter and 31 2 microns in tangential diameter, with walls 19 5 microns thick

Cotypes —Collection of Willard Berry No L-22

Occurrence —Talara shale 958 feet above base, northwestern Peru

L samanica, which is next to the largest *Lepidocyclina* in this sandstone does not seem to be related to any described form and can easily be recognized by its large size and the ratio of the length to the width of the nucleoconch.

Lepidocyclina sectionensis W Berry n sp.

Fig 11

Test discoidal, equilateral, small, thin, 1 83 mm in diameter, 0 45 mm thick, ratio of diameter to thickness 4·1 Test thins evenly from the center to the periphery, with no flange Surface reticulate, sparingly papillated. Pillars polygonal in shape and 66 8 microns in diameter at the surface The lateral chambers at the surface are 100 2 microns in diameter with walls 16 7 microns thick

The nucleoconch is composed of two subequal chambers separated by a thin straight wall The width of the nucleoconch is 257 4 microns and the length 390 microns, the ratio of the length to the width is 1.5·1, the walls are 31 2 microns thick. The equatorial chambers are arranged in circles, these chambers are 39 microns in radial diameter and 42 9 microns in tangential diameter, with walls 23 4 microns thick

Cotypes.—Collection of Willard Berry No L-18

Occurrence.—Talara shale, 958 feet above base Northwestern Peru

L sectionensis has a rather characteristic arrangement of chambers around the nucleoconch On one side are 3 relatively large secondary chambers and on the other side 2 This arrangement is nearest to *L seis* and *L ocha* from the same locality but these two have 3 large secondary chambers on each side of the nucleoconch, but differ in other respects *L sectionensis* is the thinnest form from this locality

Lepidocyclina ocha W Berry n sp

Fig 4

Test discoidal, equilateral, small, thin 1 67 mm. in diameter and 0 71 mm thick, ratio of diameter to thickness 2 3.1 Test thins evenly from the center to the periphery, with no flange. Surface papillated, small and evenly spaced Pillars polygonal in shape and 50 1 microns in diameter at the surface The lateral chambers at the surface are 83 5 microns in diameter with walls 15 microns thick.

The nucleoconch is composed of two subequal chambers separated by a thin straight wall The width of the nucleoconch is 195 microns and the length is 273 3 microns, the ratio of the length to the width is 1.4.1, with walls 19 5 microns thick The equatorial chambers are arcuate-rhombic and are arranged in circles, these chambers are 39 microns in radial diameter and 31 2 microns in tangential diameter with walls 19 5 microns thick

Cotypes.—Collection of Willard Berry No L-19

Occurrence.—Talara shale, 958 feet above base, northwestern Peru

L ocha is like *L seis* and *L arena* in having 3 relatively large secondary chambers on both sides of the nucleoconch In ratio of length to width of the nucleoconch it is like *L samanica* but differs in all other respects It is easily recognized in thin section by the 3 secondary chambers on each side of the nucleoconch and the heaviness of the equatorial chamber walls

Lepidocyclina gritta W Berry n sp

Fig 9.

Test discoidal, equilateral, small, thin, 2 08 mm in diameter, 0 60 mm thick, ratio of diameter to thickness 3 4+:1 Test thins evenly from the center to the periphery, with no flange Surface papillated, small, and evenly spaced Pillars polygonal in shape and 50 1 microns in diameter at the surface The lateral chambers at the surface are 83 5 microns in diameter with walls 16 microns thick

The nucleoconch is composed of two subequal chambers separated by a thin, straight wall The width of the nucleoconch is 292 8 microns and the length is 331 5 microns, the ratio of the length to the width is 1 13+:1, with walls 27 3 microns thick The equatorial chambers are arcuate to hexagonal and are arranged part in circles and part in columns, these chambers are 58 5 microns in radial diameter and 58 microns in tangential diameter with walls 17 microns thick.

Cotypes.—Collection of Willard Berry No L-20

Occurrence.—Talara shale, 958 feet above base, northwestern Peru

L gritta can be easily recognized in thin section by the way the equatorial chambers are first arcuate and in circles, then hexagonal and arranged in columns and then arcuate and in circles. It is entirely unlike any described form

Lepidocyclina ariena W. Berry n sp

Fig 6

Test discoidal, equilateral, small, thin, 1 70 mm in diameter, 0 62 mm thick, ratio of diameter to thickness 2 7+ ·1. Test thins evenly from the center to the periphery, with no flange Surface papillated, very noticeable, and fairly evenly spaced. Pillars polygonal in shape and 83 microns in diameter at the surface The lateral chambers at the surface are 133 6 microns in diameter with walls 33 4 microns thick.

The nucleoconch is composed of two subequal chambers separated by a thin straight wall. The width of the nucleoconch is 245 7 microns and the length is 351 microns, the ratio of the length to the width is 1 42+:1, with walls 31 2 microns thick. The equatorial chambers are open-arcuate and are arranged in circles: these chambers are 31 2 microns in radial diameter and 27.3 microns in tangential diameter with walls 23.4 microns thick

Cotypes—Collection of Willard Berry No L-21

Occurrence.—Talara shale, 958 feet above base, northwestern Peru

L. ariena is like *L ocha* and *L seis* in having 3 relatively large secondary chambers on either side of the nucleoconch but differs in all other respects It is the smallest *Lepidocyclina* found in the formation and can easily be recognized by the smallness of the equatorial chambers

Lepidocyclina seis W Berry n sp

Fig 3

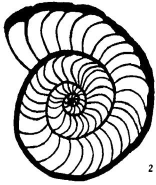
Test discoidal, irregularly equilateral, fairly large, thin, 3 34 mm in diameter, 1.5 mm thick, ratio of diameter to thickness 2 2+.1 Test thins evenly to within 0 4 mm of the periphery, where there is a narrow flange, diameter of central boss 2 54 mm Surface papillated, fairly large and slightly more numerous on the boss, otherwise evenly spaced Pillars polygonal, 133 6 microns in diameter at the surface The lateral chambers at the surface are 50 1 microns in diameter with walls 20 microns thick

The nucleoconch is composed of two subequal chambers separated by a thin straight wall The width of the nucleoconch is 249 6 microns and the length is 347 1 microns, the ratio of length to the width is 1 39− ·1, with walls 27 3 microns thick The equatorial chambers are arcuate-hexagonal and are arranged in circles to columns, these chambers are 39 microns in radial diameter and 42 7 microns in tangential diameter with walls 13.7 microns thick

Cotypes—Collection of Willard Berry No. L-24

Occurrence—Talara shale, 958 feet above base, northwestern Peru

L seis is very characteristic in thin section as the equatorial chambers are first arranged in circles but about half way to the periphery they are arranged in columns See *L ariena* and *L ocha* for comparison with those species



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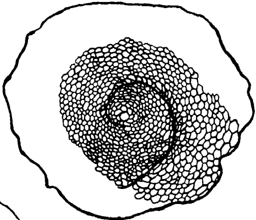

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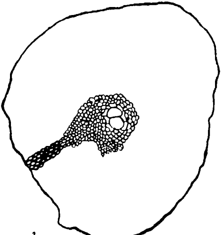

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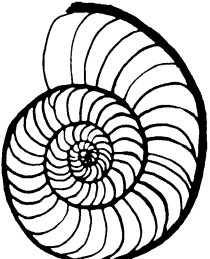

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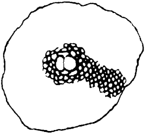

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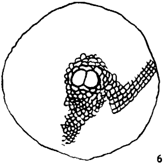
Fig 1—*Lepidocyclina (Helicolepidina) august-tobleri* n sp ×20
Fig 2—*Operculina samanica* n sp ×20
Fig 3—*Lepidocyclina seis* n sp ×20
Fig 4—*Lepidocyclina ocha* n sp ×30
Fig 5—*Operculina atascaderensis* var *samanica* n var ×20



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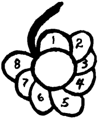

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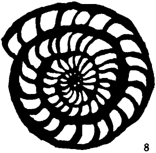

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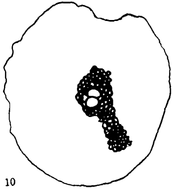

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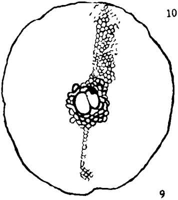

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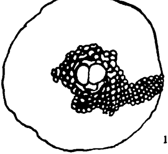

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Fig 6—*Lepidocyclina ariena* n sp ×25

Fig 7—Nucleoconch *H august-tobleri* ×64, Chambers 1–8 are primarily spiral chambers

Fig 8—*Operculina talara* n sp ×25

Fig 9—*Lepidocyclina gritta* n sp ×25

Fig 10—*Lepidocyclina samanica* n sp ×20

Fig 11—*Lepidocyclina sectionensis* n sp ×20

Subgenus *Helicolepidina*

Helicolepidina august-tobleri W. Berry n sp.

Fig. 1

Test discoidal, equilateral, large, fairly thick, 3 74 mm. in diameter, 1 00 mm thick, ratio of diameter to thickness 3.74:1. Test thins evenly from center to within about 0.333 mm of periphery where it thins more slowly, producing a pronounced flange Central boss 3.072 mm. in diameter. Surface papillated, small and evenly spaced, the papillae on the boss being slightly greater in diameter Pillars polygonal in shape and 566 8 microns in diameter at the surface The lateral chambers at the surface are 83 5 microns in diameter with walls 17 microns thick.

The nucleoconch is composed of one nearly circular chamber surrounded by eight inner primary spiral chambers (see Fig 7.). The first circular chamber is 156 microns in diameter with walls 23 4 microns thick The secondary spiral chambers are somewhat arcuate in shape, and make about $1\frac{1}{4}$ coils before reaching the periphery. The normal equatorial chambers are open-arcuate to hexagonal and average about 78 microns in radial diameter and 78 microns in tangential diameter with walls 15 6 microns thick

Cotypes —Collection of Willard Berry No L-23

Occurrence —Talara shale, 958 feet above base, northwestern Peru.

H. august-tobleri resembles *H. spiralis* Tobler from the Priabonian of Trinidad and Venezuela in general aspect In thin section it is easily recognized by having 8 primary spiral chambers and not 4 as in Tobler's species It does not closely resemble the *Helicolepidina* mentioned from the Verdun grits of Peru. It is named in honor of the author of the subgenus, the late Dr A Tobler of Switzerland

Genus OPERCULINA

Operculina atascaderensis W Berry var **samanica** W Berry n var

Fig 5.

Test medium to large, 3 67 mm in diameter, and 0 80 mm. thick, ratio of diameter to thickness 4 5:1. Entire test about the same thickness Surface ornamented by raised suture lines The test starts with a well defined nucleoconch then makes 3 gradually increasing coils, the last coil containing 29 chambers. The septa are curved convexly outward. In the last two coils there are several septa which are compound or double on the inner end, and single on the outward end.

Cotypes.—Collection of Willard Berry No. O-7

Occurrence —Talara shale, 958 feet above base, northwestern Peru.

This variety is very close to *O atascaderensis* from the Atascadero limestone (Saman conglomerate) It is probably a descendant of *O. atascaderensis* but differs from the parent in having the septa dividing near the outward and not the inner end This variety is quite like *O irregularis* Reuss described from Oberburg in Steiermark. It is easily recognized in thin section by the character of the dividing septa

Operculina talara W Berry n sp

Fig. 8

Test small, 1 58 mm. in diameter and 0 5 m thick, ratio of diameter to thickness 3.16:1. Test much thicker at center than at periphery Surface ornamented with raised suture lines Test starts with poorly defined nucleoconch then makes about 3 very slowly increasing coils, the last coil containing about 22 chambers The septa are slightly curved convexly outward except their outward ends where they are strongly bent backwards The walls are very heavy often being about ⅓ the height of the chambers in thickness and the septa about ⅓ the width of the chambers in thickness
Cotypes —Collection of Willard Berry No O-9
Occurrence --Talara shale, 958 feet above base, northwestern Peru

O. talara seems to bear a slight resemblence to *O vaughani* Cushman, described from the Ocala limestone and the Brito formation, in the number of coils and the number of chambers in the last coil Otherwise they differ greatly. The new form is easily recognized by the extremely thick walls of the chambers.

Operculina samanica W Berry n sp

Fig 2

Test medium, 2 34 mm in diameter and 0 40 mm thick, ratio of diameter to thickness 5 68.1 Entire test about the same thickness Surface smooth except for slightly raised suture lines Test starts with a poorly defined nucleoconch, then makes about 3½ gradually increasing coils, the last coil containing 28 chambers The septa are curved convexly outward, the outer end often curving a little more sharply than the rest
Cotypes —Collection of Willard Berry No O-8
Occurrence —Talara shale, 958 feet above base, northwestern Peru

O. samanica might be confused with *O peruviana* W Berry but it has a greater number of chambers in the last coil and the septa are much less curved and more regular

ENTOMOLOGY.—*New genera and species of leafhoppers related to* Scaphoideus.[1] E. D. BALL, University of Arizona

The writer in preparing a paper on the food plants, life histories and larval characters of the species of *Scaphoideus* was impressed with the fact that there were a number of groups included that were structurally distinct and in a number of cases had quite distinct food habits and ecological relationships. It appeared to be necessary, therefore, to recognize these groups, describe some new species and discuss some apparent synonomy before such a paper could be satisfactorily prepared.

[1] Received November 14, 1931

Key to the Genera of North American Forms Formerly Included in the Genus Scaphoideus

A. Ocelli small, close to the eyes—elytral nervures not minutely interrupted with white

B. Central anteapical cell strongly constricted and divided, two cross nervures and usually a definite saddle-like marking 1 **Sanctanus** n. gen

BB. Central anteapical not divided, a single cross nervure, except rarely in *Scaphoideus* (*sensus strict.*), no definite saddle marking

C One to three supernumerary oblique veinlets to costa in the region of the outer anteapical. The outer claval distant from the inner margin of clavus, then bent suddenly at nearly a right angle on approaching the margin (an oblique dark mark often obscuring it and making it appear to be reflexed), usually 2 or 3 lobate ivory areas along suture.

D. No reticulations along claval suture or costa (except as above), outer anteapical cell oblique Male plates terminating abruptly . 2 Scaphoideus Uhl

DD. Claval suture and costa heavily reticulate Outer anteapical cell parallel with costa Male plates with filamentous appendages . . .3 **Prescottia** n. gen

CC No extra veinlets to costa in the region of the outer anteapical cell which is parallel to costa Claval veinlets normal Male plates with attenuate appendages . 4 **Osbornellus** n gen

AA Ocelli large, about equidistant from eyes and apex of vertex, outer apical parallel with costa, nervures interrupted with minute white points. . 5. **Portanus** n gen

Genus **Sanctanus** Ball n gen.

Resembling *Scaphoideus* (*sensus strict*) in the long antennae and in the posterior bristles in groups, more nearly the shape of *Aligia*, especially in the broader face and broader elytra Strikingly distinct from either in the presence of the second cross nervure between the sectors, and the constricted and divided central anteapical cell. The outer anteapical is usually narrow at both ends and there is usually one or more reflexed veinlets to costa as well as extra reticulations in some cells The vertex is shorter or about equalling the length of the pronotum, rounding or angular, the disc very slightly convex, meeting the front in an acute angle The front is broad above, narrowing rapidly with straight sutures to the narrow clypeus, which is slightly wedge-shaped and narrowing towards the apex rather than expanding as in *Scaphoideus* and *Aligia* Most species have a saddle pattern of marking which obscures the venation

Type of the genus, *Scaphoideus sanctus* Say

This genus will include *sanctus* Say (= *picturatus* Osb), *fasciatus* Osb (= *neglectus* Osb), *cruciatus* Osb , *orbiculatus* Ball, *Deltocephalus aestuarians* De L & S , *D limicolus* Osb , *D eburneus* DeL , *D fusconotatus* Osb , and probably one or two others that have been described as species of *Deltocephalus* They are, however, far removed from that group in habits, food-plants and relationships An examination of the types and long series shows no character that will warrant separation of *neglectus* from *fasciatus*

Sanctanus orbiculatus Ball n. sp.

Resembling *sanctus* but smaller with a shorter vertex and narrower light band. Reddish salmon with white markings and four black spots on vertex margin. Length ♀ 5 mm. ♂ 4 mm.

Vertex obtusely angled, broader than long, resembling *fasciatus*, the margin rounding over at the ocelli and only becoming angled with the front at the apex. Front and clypeus as in *sanctus* the front more inflated Elytra very long and slender and easily broken at apex Venation of *sanctus* nearly, the central anteapical constricted but only occasionally divided Female segment with a slight median production. Male valve very broad, rounding, plates long actuately triangular with the extremely long slightly curved black styles appearing beyond.

Color Reddish salmon above and below with black and white markings Vertex white with a short angular line under the apex and two spots above, the ocelli in a pair of large spots and a still larger pair at the base, sometimes wanting in the male Pronotum and scutellum pale in the female, reddish salmon in the male Elytra pale salmon with a smoky cast in the female, reddish salmon in the male. The scutellar margins broadly white in the female. A narrow white band across the bases of the anteapicals, the nervures beyond it white with smoky margins, a narrow smoky apical band and a large round eye-like black spot in the second apical cell

Holotype ♀ allotype ♂ and twelve paratypes all taken by the writer at Patagonia, Arizona, Sept 7, 1929

A strikingly distinct species by the salmon color and the eye spot

Genus SCAPHOIDEUS Uhl

To this genus as defined by its type *immistus* belong only those forms with the outer anteapical cell oblique, the anterior "base" usually carrying a group of about three oblique veinlets to the costa The commissure usually has a broad ivory white stripe that is divided into two or three lobes by oblique dark lines These lines occur near the apices of the claval nervures and have been mistaken for the nervures themselves and thus the nervures have been described as "strongly hooked " By use of transmitted light one discovers that the outer claval nervures while at some distance from the margins are strongly bent and approach the margin at nearly right angles regardless of the direction of the dark markings

There are a number of very closely related species in this group whose specific limits will not be accurately defined until their food plants have been determined and good series of known origins are available for study Where such series have been secured restricted variation has been found to be the rule and constant characters can be defined.

The species may be roughly divided into three groups, as follows

1 *Face generally pale* There may be some irregular color besides the dark lines above but the general ground color is pale To this group belongs *productus* Osb (*carinatus* Osb and *magnus* Osb) apparently a single very large and distinct species easily recognized by the vertex marking and broad

short male plates shown for *magnus* by Osborn; *immistus* Say (including var. *incisus* Osb which was never described) var. *minor* Osb. apparently a distinct species, *cyprius* Ball, *paludosus* Ball, *ochraceous* Osb., *intricatus* Uhl and *triunatus* Ball.

2 *Face black or brown* There may be light areas in a few cases but the general color is dark To this group belongs *sensibilis* Ball, *nigricans* Osb., *inundatus* Ball, *melanotus* Osb (which appears to be a definite and constantly marked species), *obtusus* Osb and *cinerosus* Osb , which appear to represent a single gray form, and *atlantus* Ball.

3 *Face uniformly tawny or reddish rather than dark.* To this group belongs *opalinus* Osb , *littoralis* Ball, and *luteolus* V. D., three species whose food habits are definitely known The face color of *opalinus* was not described. It is darker than that of the pronotum, pale brown with a fulvous or coppery reflection

Scaphoideus immistus var. **titanus** Ball n. var

Form and structure of the species, calvus and adjacent corium dark brown or black with the lobate areas and one or more pairs of ivory spots in sharp contrast Vertex ivory with a very narrow transverse band tawny, pronotum and scutellum pale cinereus with only traces of light markings. Elytra very dark except for the ivory marking, the apex with a broad smoky band. The costal area and an area before the apical cells pale with the nervures broadly smoky Face and below pale, female with two black lines below vertex margin and traces of two dark areas on front, male with one brown line and traces of another

Holotype ♀ Morgantown, West Virginia, August 12 Allotype ♂ Toronto, Ontario, August 8, 1921, and one paratype male, Fairmont, West Virginia, August 21, 1927

This is either a striking color variety or a distinct species of which we should know more

Scaphoideus cyprius Ball n sp

Size and general form of *immistus* but with an almost uniformly coppery shade slightly darker than in *luteolus* Face pale Length ♀ 5 5-6 mm , ♂ 5 mm.

Vertex about as in *intricatus*, right-angled or very slightly acute, shorter in the male Elytra as in *immistus*, the venation similar Female segment with the posterior margin rounding or slightly angularly produced and dark marked. Male valve inconspicuous, plates together long, narrow, spoon-shaped Pygofers in both sexes with four tufts of black bristles.

Color. Pale coppery, vertex ivory, a narrow black line on anterior margin and a rather narrow transverse tawny band. Pronotum and scutellum tawny shading to coppery, a faint transverse ivory band just back of the eyes and a definite yellowish ivory band back of the suture of the scutellum Elytra almost uniform coppery, the nervures scarcely darker except in the region of the costal and anteapical cells, a narrow elongated lobate spot and two pairs of irregular areas in the inner anteapical cells ivory, and the nodal cells milky. Face and below creamy, the females with two and the males with one dark line under the vertex margin The males are paler than the females

Holotype ♀ and two paratypes females August 7, 1897 Allotype ♂ and two paratype females July 14, 1896, three paratypes July 20 and July 30, 1896 and August 9, 1895, all taken at Ames, Iowa by the writer.

Examples of this species were mixed with those of *intricatus* and it was only when the following species was being compared that the mistake was discovered.

Scaphoideus paludosus Ball n sp

Resembling *cyprius* in form and general coloring, broader with a broader shorter head, tawny with ivory spots and lobate markings Length ♀ 6 mm. ♂ 5 mm.

Vertex right-angled, length equalling its basal width, shorter than the pronotum. Elytra proportionally broader than in *cyprius* with the venation similar. The claval nervures approaching each other and sometimes united by a cross nervure. Outer anteapical cell oblique but rarely stylate (as in allotype). Three reflexed veinlets from its basal half Female segment with the posterior margin very slightly rounding and lacking the black band Male plates slightly shorter and broader at the apex than in *cyprius*

Color Tawny, slightly more orange than in *luteolus*, with a light creamy face Vertex ivory with a narrow tawny band that has a median point Pronotum tawny with an indistinct ivory band behind the eyes Scutellum pale tawny with the apical third lighter, margined by two black dots Elytra tawny with rusty nervures before the apical cells, a narrow but definite smoky band at the apex and a few dark dots Two lobate areas along the commissure and two or three pairs of ivory spots Face and all below creamy white, two narrow black lines below the vertex margin in both sexes

Holotype ♀ Sanford, Florida, July 20, 1927 (Ball). Allotype ♂ Bradenton, Florida, June 11, 1928 (W E. Stone), and two paratypes females Sanford, July 10 and 29, 1926 (Ball & Stone) and one female Plant City, Florida, June 23, 1926 (Dr Baer), all taken along the margins of deep swamps.

Scaphoideus triunatus Ball n sp

Size of *magnus*, nearly, but more slender, general appearance of *sensibilis*, four broad transverse brown bands set off by five broad white ones on dorsum of body. Length ♀ 6 mm ♂ 5 25 mm

Vertex definitely acutely angular, more than half its length before the eyes, equalling the pronotum in length. Elytra narrowly appressed, giving a slender appearance Venation as in *immistus*, the outer anteapical cell oblique but rarely pointed or stylate posteriorly, rarely more than two oblique nervures to costa from its base What appears to be a second cross nervure often present Female segment rounding and black-bordered posteriorly, male valve as long as wide, acutely rounding. The plates together extremely long spoon-shaped, the apices rounding and clothed with fine hairs

Color. General color slightly tawny brown, males lighter. Vertex, pronotum, and scutellum ivory white with four broad transverse brown bands as follows: one like a flying bird across the middle of vertex, a second covering the anterior fourth of pronotum, an interrupted one dividing the remainder of the pronotum, and a broader one occupying the basal half of the scutellum. Elytra subhyaline with heavy rusty nervures, a black cloud at apex, a smoky cloud across and behind the cross nervure and another surrounding the three definite lobate ivory areas along the commissure Face and below white, a single black line below the vertex margin in the male, a pair in the female, as in *ochraceus*.

Holotype ♀ allotype ♂ and twelve paratypes taken by the writer July 17, 1929, at Granite Dells, Arizona

Scaphoideus atlantus Ball n sp

Similar to *immistus* in form and structure, larger. Size and general appearance of *auronitens* Dark copper with three pairs of black dots and no lobate areas along commissure Length ♂ 5 mm

Vertex (in male) obtusely angulate, one-half longer than against eye, about two-thirds the length of pronotum Elytra long narrow appressed. Venation of the *immistus* type obscured by the coppery shade, no cross nervure on clavus, the outer anteapical cell oblique but narrowing about equally at each end with three reflexed nervures to costa from the basal half Male valve obtusely rounding, plates together twice as long as their basal width scarcely narrowing before the abrupt, slightly oblique apices

Color. Vertex ivory before the eyes with a definite black line on the margin, a broad tawny band on the disc shading out posteriorly to leave a creamy line at the base Pronotum uniform dark coppery, scutellum a little paler with two black dots at apex Elytra of a uniform dark copper tint with a broad apical band smoky, the nervures just before this rusty, the remainder obscure, three pairs of black dots along the commissure Face pale brown with a coppery reflection, a black line under vertex margin bordered on both sides with ivory, below this traces of one or two pale arcs on the front. Legs and below white, the venter dark

Holotype ♂ Glassboro, New Jersey, July 29, 1927

This is so strikingly distinct in this group and so near like *auronitens* except for the vertex markings and venation that it was thought best to describe it from a single example in hopes that others might be found in collections and lead to a food-plant record

Scaphoideus sensibilis Ball n sp

A large black species resembling *magnus* in size and *nigricans* in color but with more definite alternation of ivory and black Length ♀ 6 mm , ♂ 5 mm.

Vertex right-angled the apex rounding, less pointed than in *magnus* with a more definite notch in the posterior border Pronotum as in *immistus*. Elytra long, inclined to be appressed Venation as in *magnus* but with the central anteapical cell more constricted, the outer cell longer and narrower with the two ends nearer alike. Female segment long, narrowing posteriorly, the posterior margin angularly produced one-third the length of the segment, the lateral margins of the produced portion concave, the apex obtusely triangular, whole produced part shining black, the black extending half way to the base on the median line Male valve short and obtuse, plates together long and narrow, nearly twice longer than wide, their apices individually bluntly rounding and clothed with long silky hairs

Color Dark, the darkest species in the group. Vertex ivory, the usual narrow submarginal black line in front, a transverse band across the middle dark brown or black This band is narrow at the anterior angle of the eye and broadens to the middle, the posterior margin is rounding, the anterior margin convex on each side of an acute median projection The whole is the outline of a bird in flight, occupying less than one-third of the ivory disc.

Pronotum black, a curved mark enters from each posterior angle, a broad quadrangular transverse band just before the middle, a little longer than the width of vertex, a narrow median light line Scutellum with a large median shield of ivory, slightly clouded with brown in front, a pair of large black spots just inside the basal angles and a pair of points at apex. Elytra heavily clouded with smoky brown and black emphasized on nervures and apex, omitting two lobate median ivory spots and about four pairs along the claval sutures A hyaline area along costa. Face black, the front smoky with one broad ivory line below the vertex, two narrow light ones and a few partial arcs below that. Legs and all below white except for the tarsal joints and the apex of female segment

Holotype ♀ July 10, 1926, allotype ♂ July 16, 1926, and 20 paratypes taken at Sanford, Florida, from June 19 to July 16, 1926, by W. E Stone, J. A Reeves and the writer

Scaphoideus inundatus Ball n sp.

Resembling *immistus*, slightly smaller, darker, with a longer segment and a smoky face. Length ♀ 5 mm , ♂ 4 5 mm

Vertex, as in *immistus*, very slightly acutely angled, almost as long as pronotum Elytra long, appressed Venation as in *immistus*, the claval nervures approaching and often united by a cross nervure, outer anteapical cell oval, smaller at the base than in *immistus* and only slightly or not at all stylated Female segment normal in length, posterior margin roundingly produced from just inside the lateral angles into an obtuse projection that is broadly black-marked. Male valve small obtuse, plates together elongated, broadly spoon-shaped, much exceeded by the slender elongate pygofers

Color General color brown with a tawny cast, darker than *immistus* or *melanotus* but not as dark as *sensibilis*, nor with as definite light markings Vertex creamy back to the line of the eyes, then tawny brown shading out to creamy at the base Pronotum smoky brown with a faint quadrangular light band before the middle Scutellum tawny, the apex ivory with four black dots on margin Elytra slightly milky, subhyaline, heavily washed with smoky brown on the nervures and in some of the cells The lobate ivory areas large with heavy black markings anterior to them, a broad smoky band at apex Face uniform pale brown, a broad ivory band margined by two narrow black ones under the vertex margin and a few pale areas on front below these Legs white with the usual black annuli on tarsi

Holotype ♀ allotype ♂ and 4 paratypes taken with them June 9, 1928 and ten paratypes taken from April 25 to July 31, by W. E. Stone and the writer at Sanford, Florida

This species is smaller than typical *immistus* but considerably larger than *minor* The constant dark smoky face will at once separate it from these species. From *melanotus* it is readily separated by the larger size, longer vertex and lack of definite black on face

Scaphoideus littoralis Ball n. sp

Similar to *opalinus* in form but more tawny, not as tawny as *luteolus* and more definitely marked Length ♀ 5 5 mm , ♂ 4 75 mm

Vertex about as in *opalinus*, slightly more acutely angulate, definitely longer than in *luteolus*. Elytra slightly longer than in *opalinus* Venation similar,

the outer anteapical cell longer and not as wide, narrowing posteriorly, often pointed or stylate; central anteapical cell very broad near base, slightly narrower in center than at apex Female segment typical, the posterior margin roundingly produced nearly one-third the length and shining black on the produced portion Male valve triangular, plates elongate, their apices individually rounding, both plates and valves clothed with fine hairs

Color Pale tawny with an opalescent shade on the elytra. Vertex creamy with a tawny cast, the usual sub-marginal black line, a broad band behind the middle, pale tawny. Pronotum pale tawny with an opalescent cast, traces of a quadrangular band anterior to the middle Scutellum tawny with a pair of faint stripes, a pair of dots in the basal angles and a transverse band behind the suture, ivory Elytra tawny opalescent, an apical smoky band extending to just before the cross nervures. The nervures are mostly rusty brown and there are two lobate ivory spots on the commissure and ivory spots on the claval sutures as in *opalinus* Face pale, slightly smoky in the female, with three dark bands below the vertex margin, creamy with a single band in the male. Legs and below white or pale, the disc of the abdomen and rings on the tarsi dark

Holotype ♀ allotype ♂ and twelve paratypes taken at Woods Hole, Massachusetts, by the writer, July 11, 1925

Genus **Prescottia** Ball, n. gen

Resembling *Scaphoideus* in the long antennae, the lobate commissure, and the posterior angle of the outer claval nervure Similar to *Osbornellus* in the outer anteapical paralleling the costa Related to *Twiningia* in the reticulations along the costa and claval suture.

Head narrower than the pronotum, vertex angular, broad and flat or concave with a sharp margin, forming an acute angle with the straight front Front slightly broader than in *Scaphoideus* Elytra long and appressed Venation similar to *Scaphoideus* except that the outer anteapical is parallel with the costa and has about five reflexed veinlets to costa and an equal number along the costal area The cells are more or less reticulate before the apical, especially emphasized along the claval suture but no definite second cross nervure is apparent

Type of the genus, *Scaphoideus lobatus* V D

Prescottia brickellia Ball n sp

Resembling *lobata* but much larger, darker with a broader head, a much broader vertex with a definite black line beneath the acute margin. Length ♀ 7 mm , ♂ 5 5 mm

Vertex very slightly acutely angulate, as long as its basal width in the female, shorter in the male, the margin acute Front broader than in *lobata*, elytra with the same type of reticulate venation, usually a few more veinlets to costa Female segment about as in *lobata*, the posterior margin more produced and heavily black-marked Male plates broadly rounding, then attenuately produced

Color. Vertex creamy with a fulvous cast, traces of a line around the anterior margin, a transverse band just back of the anterior margin of the eyes, a shorter one half way between this and the apex. Pronotum and scutellum creamy with a fulvous shade Pronotum with heavy brown irrorations, especially on the submargin Scutellum with orange in the angles, a pair

of spots on the disc and another pair at apex Elytra with the scutellar margin and two lobate spots on the commissure ivory The remainder heavily inscribed with brown, a smoky cloud on the apex The scutellar margin is not as broadly ivory as in *lobata* and the anterior lobate spot is elongate instead of almost circular

Holotype ♀ allotype ♂ and fifteen paratypes taken by the writer at Granite Dell, Arizona, July 17, 1929.

Genus **Osbornellus** Ball, nov gen

Resembling *Scaphoideus* in size and form with the long antennae and narrow front but lacking the oblique anteapical cell, the extra veins to costa and the claval veins are normal

Head slightly narrower than the pronotum, enclosing the anterior third Vertex flat, angled in front and forming an acute angle with the narrow face Elytra long, the venation simple, regular, a single cross nervure The claval veins normal, not forming an exaggerated angle posteriorly, the outer anteapical cell parallel to costa A single veinlet at or near each end, these together with the apex of the third apical nervure broadened and reflexed to costa. Female segment simple, the posterior margin straight or only slightly rounding Male plates elongated into filamentous or plumose processes.

Type of the genus, *Scaphoideus auronitens* Prov.

To this genus *auronitens* Prov , *ritanus* Ball, *consors* Uhl , (= *scalaris* V.D) *jucundus* Uhl , *cocanus* Ball, *albonotatus* V D and *unicolor* Osb. of our fauna have been referred and this seems to be the dominant group in the more tropical regions.

Osbornellus ritanus Ball, nov sp

Resembling *auronitens* in size and general form but with a shorter vertex, with the anterior line definitely concave on either side the apex, and no red markings. Length ♀ 6 mm., ♂ 5 75 mm.

Vertex shorter than in *auronitens*, but the apex nearly as acute because the side margins are definitely concave rather than straight or rounding as in that species The margin appears to be thicker but this is probably due to the concavity of the lateral margins allowing the black line below the margin to be visible from above Elytra as in *auronitens*, the three reflexed nervures to costa much broader, the anterior nervure arising at the base of the outer anteapical or only slightly anterior to it instead of some distance along the costal cell as is frequently the case in *auronitens* Female segment slightly produced, the pygofers with fine, almost downy hairs instead of bristles as in *auronitens*. Male plates rather broad at base and black-lined, roundingly narrowing to long filamentous white tips; pygofers black-tipped but lacking the divergent black pencils of the former species.

Color of *auronitens*, slightly darker throughout, entirely lacking the red markings and the second black band on vertex The anterior band narrower, curved or broken around the ocelli, concave before the apex allowing the band below to appear, basal markings of vertex as in *consors* ending in a spot on the suture before the middle Pronotum pale brown with a pair of points on the submargin Three pairs of dark points on the commissure, a smoky band at the apex of elytra, the costal veinlets and often a few areas in the discal cells brown Face pale smoky shading to light below, a single irregularly curved black line below the vertex margin instead of a straight one as in *auronitens*.

Holotype ♀ allotype ♂ and one paratype, Huachuca Mountains, June 15, 1930. Four paratypes from the same place, August 2, 1931. One from the Chiricahua Mountains July 6, 1930 and two from the Santa Rita Mountains, May 11, 1930 and June 30, 1929, all collected by the writer and all from high elevations in Arizona

Osbornellus cocanus Ball, n. sp.

Resembling *jucundus* but much smaller and narrower with a longer and more acutely angled vertex. Rich fulvous with oval milky spots Length ♀ 4 75 mm , ♂ 4 mm

Vertex flat, right-angled, the apex a little rounding, as long as the pronotum, a little longer than its basal width, while in *jucundus* it is definitely shorter Angle with face extremely acute, not more than two-thirds as wide as in *jucundus*, the margin thick and set off by two definite black lines. Elytra short, appressed, venation as in *jucundus*, the anterior costal nervure arising from the outer anteapical cell some distance from the base Female segment short and slightly rounding posteriorly. Male plates narrower than in *jucundus* with thread-like appendages longer than the pygofers

Color Light yellow with ivory spots and tawny or red mottling Vertex with a white line on suture at apex bisecting the dark marginal line, an elongate triangle on suture at base Outside of these are two broad slightly oblique red stripes slightly obscured in the female Pronotum irregularly washed with tawny, scutellum tawny with seven white points Elytra tawny shading to subhyaline on the margin, the nervures definitely rusty, growing darker posteriorly, a brown cloud in the apical cells Face tawny

Holotype ♀ Cocoa May 5, 1926, allotype ♂ Sanford, May 1, 1927, and two paratype males Sanford, May 12, 1926 and May 14, 1927. All taken in Florida by W E Stone and the writer

This is a beautiful little species about half the size of *jucundus*.

Genus **Portanus** Ball, n. gen

Resembling *Scaphoideus* in general form and appearance Venation as in *Osbornellus* Strikingly distinct from either in the round white spots along the nervures and the ocelli located in slight pits almost halfway from the eye to the apex of vertex

Head definitely narrower than the body, enclosing one-half the pronotum Vertex flat between the eyes, then rounding over and joining with the inflated front in an obtusely pointed cone, with the large ocelli in pits above the margin half way to the apex Antennae elongate as in *Scaphoideus*, set in a deep pit or groove formed by the inflated front. Front convex in both diameters, nearly parallel margined until just before the apex Elytra extremely long and narrow Venation regular, the cells long and narrow, the outer anteapical extremely long, parallel with the costa, nervures to costa short straight Female segment short and truncate

Type of the genus, *Scaphoideus stigmosus* Uhl

Uhler's species was described from the West Indies Examples of what is apparently *mexicanus* Osb from Guatemala have been compared with the type of *stigmosus* and are no doubt the same *S longicornis* Osb. from Bolivia also belongs to this genus

Genus TWININGIA Ball

The author has previously referred *Scaphoideus blandus* Ball, *pellucidus* Ball (= *irroratus* Osb) *fumidus* Ball and *bicolor* Ball to this genus and described *magnata* and *malvastra* These forms are related to *Mesamia* rather than to *Scaphoideus*

PALEONTOLOGY.—*A new species of* Cancer *from the Pliocene of the Los Angeles basin.*[1] MARY J. RATHBUN, National Museum.

From Prof. U. S. Grant, University of California, Los Angeles, has been received for report a species of *Cancer* unlike any hitherto described.

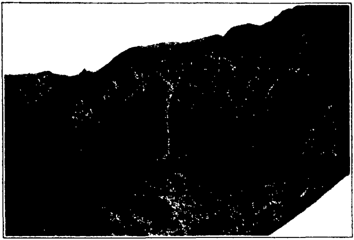

Fig 1 *Cancer granti* Rathbun, sp nov Anterior portion of carapace, × 1½

Cancer granti Rathbun, sp nov

Fig 1

A portion of the anterior half of the carapace is exposed, surface thickly covered with minute punctae, granules visible to the naked eye are loosely scattered in groups on the protogastric, mesogastric, hepatic and epibranchial regions, a tubercle behind inner angle of orbit, interregional grooves shallow; anterior and antero-lateral margins bordered by elongate granules or blunt spinules, lateral teeth upturned, the second tooth from the orbit is narrow, little more than half as wide as the third tooth, fourth and fifth teeth subequal, slightly narrower than third, the surface of the front between orbits has 3 longitudinal furrows, the margin is obscure. Estimated width of carapace 56 5 mm

[1] Received November 23, 1931

SCIENTIFIC NOTES AND NEWS

To Dr. ANDREW ELLICOTT DOUGLASS, Director of Steward Observatory of the University of Arizona, and to Dr ERNST ANTEVS, of the University of Stockholm, Sweden, were awarded on December 18, 1931, prizes of $2,500 given by the Research Corporation of New York City through the Smithsonian Institution. By studying the annual growth rings of trees in the Southwest, Dr DOUGLASS has established an unbroken chronology back to the beginning of the eighth century, through which the dates of construction of prehistoric pueblos in that region have been determined. Dr. ANTEVS has supplied another record of weather in the past through a study of laminated clay deposits known as varves, left in the wake of melting glaciers.

Obituary

SAMUEL WESLEY STRATTON, former Director of the National Bureau of Standards and President of the Massachusetts Institute of Technology, died at his home in Cambridge on October 18, 1931, shortly after dictating a tribute to THOMAS A. EDISON. Dr. STRATTON was born at Litchfield, Ill, on July 18, 1861. He received the degree of Bachelor of Science from the University of Illinois in 1884, Doctor of Engineering from the same University in 1903, Doctor of Science from Western University of Pennsylvania in 1903, Cambridge in 1908, Yale in 1919, Doctor of Laws from Harvard in 1923, and Doctor of Philosophy from Rensselaer in 1924. From 1885–92 he served as instructor in mathematics, associate professor and professor of physics and electrical engineering at the University of Illinois He was successively assistant professor, associate professor and professor of physics at the University of Chicago from 1892 to 1901 He became the director of the National Bureau of Standards at its founding in 1901 and held this office until his voluntary retirement in 1923 to accept appointment as president of the Massachusetts Institute of Technology. He later became president of the board of the same institution.

Dr. STRATTON was a member of the American Physical Society, American Association for the Advancement of Science, American Institute of Electrical Engineers, American Society of Mechanical Engineers, American Philosophical Society, National Academy of Sciences, National Research Council, National Advisory Committee for Aeronautics, National Screw Thread Commission, and the International Commission on Weights and Measures. While resident in Washington, he was a member of the Washington Academy of Sciences.

Dr STRATTON was made a Chevalier of the Legion of Honor in 1909, and an Officer in 1928. He was awarded the Elliott Cresson medal of the Franklin Institute in 1912 and the public welfare medal of the National Academy in 1917.

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CHEMISTRY.—*The scientific work of Charles James.*[1] B. S. HOPKINS, University of Illinois (Communicated by R. C. WELLS.)

Usually the chemist regards work with the rare-earth group with indifference, lack of interest, or even disdain. He is very apt to believe that the long-continued fractionations would exhaust his patience, the enormously complex mixtures of similar substances would overtax his ingenuity, the lack of efficient means of separation would dampen his enthusiasm and the high cost of material as well as the necessary wastefulness in its refinement would overpower his courage. Usually in selecting a field to which he may devote his years of active and intensive study, the chemist is of necessity restricted by the thought of the probable usefulness of his results. The worker in the rare-earth field is foredoomed to the knowledge that his results will be branded by that scathing comment of the practical man. "It is of scientific interest only." The deliberate selection of this field for one's life work requires a courage, resourcefulness, patience and thorough devotion to scientific achievement which is possessed by few men. In Professor James as in few men in our generation there were combined those sterling qualities of character and mind which are essential to success in this field. He was patient in his work, willing to retire from the busy whirl of modern life to the quiet of his laboratory. He possessed a remarkable ingenuity for devising new methods for work, his enthusiasm was contagious and he never lost sight of the fact that true scientific progress comes not from lucky chance discoveries but as the result of patient, painstaking effort. He inspired his students with a love for chemistry and a devotion to truth, his vision extended far beyond that of the practical mind for he realized that true progress is made by advancing the scope of human knowledge. He saw that in the rare-

[1] Reprinted, by permission, from *The Nucleus* (October, 1931), published by the Northeastern Section of the American Chemical Society Received November 6, 1931

earth group there were involved many problems the solution of which would go far toward unravelling much of the mystery of the Periodic Table. He believed not only that the elements of the rare-earth group held the key to a vast storehouse of scientific knowledge but also that when their true relationship was understood they would find important applications in our complex modern life. To him the rare earths were not a theory but a problem, the solution of which was destined to contribute materially to the comfort and welfare of the human race.

The outstanding contribution which Professor James has made in the technical field of the rare-earth group is unquestionably his remarkable ingenuity for devising new methods of separations. The methods which were used by the early workers in this field were largely empirical in their nature, extremely wasteful and with low efficiency. Many of the methods now in use were suggested or developed by Professor James. He studied the bromates more fully than any of his predecessors and from this study he worked out a method which has been successful in separating the members of the cerium group. Later this same method has been applied to the study of the yttrium group with the result that it has definitely contributed to the chemistry of these elements. Another method for which we are indebted to Professor James is that in which the separations are due to the fractional hydrolysis of the nitrites This method has been used successfully in the separation of the members of the yttrium group and it has been used directly in the preparation of material used in determining the atomic weights of yttrium, holmium, erbium, dysprosium, and other members of the group. Probably the most widely used method of separating the members of the rare-earth group into fractions from which the salts of individual members may be obtained is the one which employs the fractional crystallization of the double-magnesium rare-earth nitrates. This is frequently referred to as the James method, because we are indebted to him and his co-workers for this convenient and useful process.

In addition to these well-known and widely-used methods he has contributed many other processes which are available for specific purposes. He found that ammonium sebacate was useful in removing the alkali from the members of the yttrium group; he published the method of removing cerium as the iodate and bromate, and he brought about separations by the use of the carbonates, cacodylates, dimethylphosphates, cobalticyanides and many other salts In pursuing his work along such lines he studied the behavior of a large number of salts many of which it may safely be claimed had never been prepared pre-

viously. Among such compounds may be mentioned the pyromucates, propionates, citrates, tungstates, m-nitrobenzoates, camphorates, phenyloxyacetates, diphenylsulfonates, and the bromo-nitrobenzene-sulfonates. He prepared a general scheme of separation for the entire group and as he succeeded in making refinements from time to time, this scheme was revised and improved

Professor James recognized the desirability of introducing more exact methods into rare-earth work and accordingly he devoted considerable time to the adaptation of analytical procedures to this field. Realizing the need of more accurate scientific information he determined the solubilities of many of the rare-earth salts under various circumstances, and his study of the solubility of the rare-earth bromates is the most complete record in existence. These details have been of untold value in promoting skillful rare-earth work He has made extensive studies upon the problem of the quantitative determination of the individual members of the rare-earth group. This is an extremely difficult task because of the similarity of the members of this group, their close resemblance to several of the neighboring elements and the marked tendency of their precipitates to occlude various materials from solution. In spite of such handicaps successful methods were devised and many have become standard practice where such work is required We are indebted to the James laboratory for methods for the quantitative determination of yttrium, lanthanum, neodymium, and cerium, he likewise pointed out some of the errors which were unavoidable in the older methods.

Few problems in the whole field of chemistry require greater skill and care in every minute detail than is needed in the determination of atomic weights. Such work in the rare-earth group is doubly difficult because of the tremendous task which is imposed by the difficulty in preparing material of atomic weight purity Professor James and his coworkers were particularly successful in this field because of the skill developed in handling rare-earth material His determinations include the value of thulium, samarium, and yttrium It is very significant to observe that the values which he found are almost exactly those which are now accepted by the International Committee

When Professor James began his work upon the rare-earth group there was much confusion concerning the number of elements which should be included as well as in their relationship to one another. Some of the elements were regarded as existing in a meta form and thulium was said to consist of a mixture of thulium I, thulium II, thulium III. The James laboratory made a special and exhaustive

study of the behavior of thulium and finally succeeded in establishing the fact that thulium is a definite chemical individual and that there is no reason for believing it to be other than a single element. Much confusion also prevailed concerning the elements of high atomic weight. Professor James applied himself with his characteristic zeal to the study of this portion of the group and it has been reported that in his laboratory he had succeeded in separating the compounds of lutecium before the discovery of this element was reported from a European laboratory. With his characteristic thoroughness he had waited for a confirmation of his first results, so the honor of this discovery went elsewhere. In a closely similar situation Professor James had long been interested in the presence of element No. 61, which had been predicted years before the work of Moseley Careful search through many years had failed to reveal any indication of the presence of this element. But at last he had succeeded in effecting a partial separation, but while his material was being subjected to X-ray analysis at the University of Michigan the announcement of this discovery of element No. 61 was made from another laboratory. This fact, however, must not be interpreted as detracting from the credit due to Professor James, because his work in that field was performed with the utmost care and it must stand as representing the unusual skill and careful scientific precaution which so thoroughly characterized his work.

It must not be assumed that Professor James had no interest outside the rare-earth group. His interest extended to a study of many related elements and in this work his rare-earth experience made his investigations particularly valuable. He devised a new method of separating thorium, a separation which is of much practical value because commercial thorium is separated from rare-earth ores. He also was much interested in zirconium and its separation from the members of the rare-earth group His phenyl-arsonic acid method for the estimation of zirconium and thorium mark a great step in advance in the chemistry of these elements. Zirconium especially has long needed a definite and conclusive method for its detection and estimation. The new interest in zirconium which is reflected from hafnium and the fact that we now have definite means for its quantitative determination will undoubtedly lead to material advancement in the chemistry of this much-neglected element. In addition, Professor James made outstanding contributions to the chemistry of scandium, gallium, germanium, and beryllium.

In his later years Professor James had become interested in the rare-earth and kindred metals. He prepared in his laboratory many of the

metals and he was keenly interested in the possibilities of their commercial utilization. His work upon uranium is outstanding in its excellence and is typical of the work which he did. Although little has been published concerning his work along these lines he has built a permanent foundation upon which posterity may be expected to erect a monument of achievement which will be a fitting tribute to his memory.

Professor James was a prolific worker whose contributions to chemistry are both numerous and valuable. But no doubt the greatest professional contribution of his life was his quiet and kindly influence over the lives of his students. A list of publications reveals the fact that he has been instrumental in the training of many chemists whose names stand high in chemical circles. To train such men is to make a contribution whose influence is eternal.

BOTANY.—*Studies in Solanaceae.—I. The species of* Cestrum *collected in Venezuela up to 1930* [1] H. PITTIER, Caracas, Venezuela.

A few years ago I had undertaken the study of the Solanaceae of my Venezuelan collection, but, having been given the hope that the eminent monographer Dr. Bitter would soon revise the whole family, with inclusion of our materials and in a far more authoritative way, I gave up the matter. Dr. Bitter named and described several *Solana* and a few species belonging to other genera, exclusive of *Cestrum*. Now that death has unfortunately brought to an untimely end the work of the able German scientist, I have taken up again the examination of the Venezuelan species of the latter group, with the results given in continuation.

It will be seen that 8 species, that is to say, over one-third of the total number reported, could not be identified with any previously known and had to be described as new. Of these only two, *Cestrum Diasae* and *C. amplum*, proceed from the cold upper belt of the Andes and constitute interesting additions to the group of small, stiff-leaved species which includes besides *C. melanochloranthum*, *C. Lindeni* and *C. Miersianum*, all belonging to our flora and also characterized by their more or less violaceous flowers. Four more species, *C. dubium*, *C. calycosum*, *C. caloneurum*, and *C. bigibbosum* were collected in the cloud-forests of Galipan and Colonia Tovar, in the Coastal Range, where conditions seem to greatly favor endemism. Finally, of the two remaining species one, *C. grande*, which reaches the

[1] Received November 15, 1931

dimensions of a real tree, belongs to the *tierra caliente* and to the littoral belt, while the other, *C. meridanum*, grows in the hills of the *tierra templada* of Mérida Far as I am from sources and materials for comparison, I am aware that some of the proposed new species may possibly have been described in recent times.

One species (*Pittier* 5797) collected at Maracay (Aragua) in 1913 and of which there is a specimen in the U. S National Herbarium but none in our collection, was identified as *Cestrum nocturnum* L. This is certainly wrong, since that species appears to be essentially West Indian and Central American. Of the older species, I have collected only *C. diurnum* (in gardens), *C. alternifolium*, *C. melanochloranthum*, *C. salicifolium*, *C paniculatum*, *C Moritzi*, and *C. Miersianum*. *C. macrophyllum* has been reported from the Lower Orinoco by Rusby and Squires. *C tinctorium*, *C. potaliaefolium*, *C. tenuiflorum*, *C. laxiflorum* and *C. Lindeni* are known only from the type collections.

It is likely, since so small a part of Venezuela has been covered as yet and there are strong indications of the existence of a certain degree of endemism, that many more species remain to be discovered. From Trinidad *C. megalophyllum*, *C latifolium* (= *C. chloranthum*) and *C. subtriflorum*, all first described by Dunal, have been reported, some of which may be found on the neighboring coast of Tierra Firme. Meanwhile, the twenty-two species known to this date are grouped according to their characters in the following key:

Filamenta laevia
- Flores in apicibus ramulorum vel in axillis foliorum congesti
  - Folia 2 5 cm fere semper breviora, glabra, flores violacei, 1 5–1 9 cm longi—Crescit in Andinum frigidis ..... *C melanochloranthum*
  - Folia 3 cm longa vel longiora—In calidis
    - Corolla nivea, 9–11 mm longa, lobulis suborbicularibus, glabris, revolutis, antherae violaceae, stigma manifeste exsertum, folia glaberrima—Culta ..... *C diurnum*
    - Corolla flavo-virescens vel purpurascens, 1 5–2 5 cm longa, lobulis linearibus, marginibus intraflexis pubescentibus, antherae flavae, stigma inclusum, folia plus minusve pubescenti ..... *C. alternifolium*
- Flores in racemis simplicibus, pauciflonbus, axillaribus terminalibusve dispositi
  - Corollae tubus plus minusve cylindricus, basi 1 mm lata vel latior, apice versus plus minusve ampliatus
    - Venae primariae 6–12
      - Folia ovalia, subtus stellato-tomentosa, 4 5 cm longa vel breviora, corollae tubus 10 mm longus ..... *C Diasae*

Folia utrinque glabra
Flores 1.4 cm. longi vel breviores, folia usque ad 8 cm. longa, 2.6 cm. lata *C. tinctorium*
Flores 1.5 cm. longi vel longiores, folia 8 cm. plerumque longiora
Corollae tubus 15–16 mm. longus, folia membranacea, obovato-lanceolata, 18–25 cm. longa, 6–9 cm. lata *C. potaliaefolium*
Corollae tubus 12–13 mm. longus, folia coriacea, oblongo-elliptica, 8–13 cm. longa, 3–4 cm. lata *C. dubium*
Venae primariae 16–20, folia glabra
Folia lanceolata, 9–13 cm. longa, 1–2.5 cm. lata, inflorescentia glabra, flores 2.5 cm. longi *C. salicifolium*
Folia 4 cm. lata vel latiora, inflorescentia plus minusve cano-furfurescens, flores pro genere brevi crassique
Calyx 10 mm. longus, corolla 1.5–2 cm. longa, folia coriacea, elliptico-lanceolata *C. caloneurum*
Calyx 11.5–12.5 mm. longus, corolla 2.2 cm. longa, folia membranacea, ovato-lanceolata *C. calycosum*
Corollae tubus filiformis, basi quam 1 mm. diameter angustior
Venae primariae 18–19, calyx brevissimus, 3.4 mm. longus, folia membranacea, glaberrima, ovato-lanceolata, basi rotundata apice versus sensim attenuata *C. grande*
Venae primariae 6–9
Caules volubiles vel scandentes
Inflorescentiae terminales et axillares, anguste paniculatis, corolla 2.7 cm. longa, petioli recti *C. paniculatum*
Inflorescentiae plerumque axillares, racemosae, latae, laxae; corolla 3.8 cm. longa, petioli basi uncinato-incurvi *C. terminale*
Caules plus minusve erecti, suffrutescentes vel lignosi
Folia ovato-acuminata, 10–11 cm. longa, nervis subtus plus minusve tomentosis, flores 1.9–2.1 cm. longi, in spicis axillaribus dispositi *C. tenuiflorum*
Folia ovato-elliptica, 7.5–9.5 cm. longa, glabra glabrescentes; flores 2.3–2.8 cm. longi, in paniculis terminalibus dispositi *C. laxiflorum*
Filamenta circa basi partis liberae plus minusve glandulosa, dentulata vel geniculata
Flores in racemis axillaribus, 3.6.5 cm. longis dispositi, folia 11.5–2 cm. longa, subtus stellato-lanuginosa, corolla subglabra, 1.0–1.5 cm. longa *C. Moritzi*
Flores paniculati
Staminum filamenta infra emersionem sua dentato-appendiculata, panicula amplia, floribunda *C. nocturnum*
Staminum filamenta supra emersionem sua glandulosa, dentata vel geniculata

Panicula simplex, spiciformis et pauciflora; filamenta supra basin bigibbosa; folia magna, lanceolata, glabra, 15–28 cm. longa
C bigibbosum

Panicula plus minusve composita, folia mediocria vel parva, glandula basalis filamentorum singula vel obsoleta

Rami paniculae folia subaequantes, flores numerosissimi, violacei, folia coriacea, glabra *C. amplum*

Rami paniculae folia multo breviora

Folia 10 cm longa vel longiores, glabra

Calyx 2 6 mm longus; corollae plus minusve flavescens 8–15 mm longa, folia ovato-oblonga *C. macrophyllum*

Calyx 3 7–4 5 mm longus; corolla violacea, 17 mm. longa, folia oblongo-lanceolata *C. Lindeni*

Folia 9 cm longa vel breviora, ovales, stellato-villosis

Flores tenui, pedicellati, viridi-flavescentes, 1 5–1 7 cm. longi
C meridanum

Flores crassi, sessiles, flavo-violaceis, 2 cm longi
C. Miersianum

CESTRUM MELANOCHLORANTHUM Dunal in DC Prodr. 13^{1} 622. 1852
(Descr emend)

Arbuscula e basi ramosa, ramis virgatis, cortice rimosulo, sordido griseo, minutissime puberulo tectis, ramulis tenuibus apice versus angulosis parce pilosulis, pilis rufo-brunneis interdum glandulosis; foliis parvis, coriaceis, utrinque glabris, breviter petiolatis, petiolo plano plus minusve rufo-brunneo, laminis oblongo-ellipticis basi cuneato-attenuatis in petiolum decurrentibus apice obtusiusculis, supra obscure viridis, subtus pallidioribus venis primariis plerumque 5–7 costaque prominulis, pseudo-stipulis parvis, foliaceis, ovato-oblongis, obtusis, deciduis, floribus axillaribus subsessilibus in apicibus ramorum subcongestis, bracteis minutis, linearibus, minute pilosulis, deciduis, pedicellis brevissimis vel nullis, rufopilosulis, calyce tubuloso-cupulato, striato, 5-nervio, atro-viridi, apice plus minusve spuberulo, sinubus amplis, dentibus inaequantibus, corolla infundibuliformi, atro-purpurea, tubo e basi ad apicem sensim ampliato, striato, glabro, lobulis ovato-ellipticis, extus vix minutissime puberulis floccosisve, intus marginibusque introflexis fulvis pubescentibus, filamentis glabris, edentulis, fere usque ad medium adnatis, supra basin leviter inflatis, antheris luteis, orbiculari-ellipticis, stylo filiformi, glabro; stigmate capitato, globoso; bacca ovoidea, violacea.

Arbuscula 1–1 2 metralis Petioli 1–3 5 mm longi, laminae 1–3 cm. longae, 0 5–1 8 cm latae, Stipulae 0 5–1 cm longae. Bracteae 2–4 mm. longae Flores 1.5–1 9 cm. longi. Pedicelli 0–0 3 mm longi Calyx 2–4 mm longus, ore 2 mm diam Corolla 1 3–1 7 cm. longa, lobulis 3 5–3 7 mm longis Staminum pars libera circa 8 mm. longa. Stylus 1.4 cm longus Bacca 6 mm longa, 4 8 mm diam

MÉRIDA. Near El Portachuelo, de Mucuchíes (*Funck & Schlim* 1264 in herb D.C., type), Páramo de El Molino, 3000 m., flowers January 22, 1922 (*A. Jahn* 923), San Rafael de Mucuchíes, 3150 m , flowers January 21, 1922 (*A. Jahn* 811); same locality, in low bushes along river, flowers February 6, 1928 (*Pittier* 12911), same locality, along Quebrada de Saysay; flowers

June 25, 1930 (*Gehriger* 40), Mucurubá, 2700–3000 m ; flowers and fruits June 25, 1930 (*Gehriger* 255)

Notwithstanding small discrepancies, as in the dimensions of the several parts, the number of primary veins, etc , I think that the specimens examined by me are conspecific with the plant of Funck & Schlim

CESTRUM DIURNUM L Sp Pl 1: 191 1753

This fine species, which seems to be indigenous in some of the West Indian Islands, is known in Venezuela only as an ornamental, under the name of *Dama de noche* (Lady of night), a mistaken denomination since the sweet-scented flowers are permanently perfumed, though perhaps less during the day The plant is distinguished from all its Venezuelan congeners by its pure white corollas and the exserted stigmas

CESTRUM ALTERNIFOLIUM (Jacq.) O E Schulz in Urban, Symb Antill **6**: 270 1909–1910

Cestrum vespertinum L Mant **2**: 206 1771

We have in the Venezuelan herbarium no less than five distinct collections proceeding from several districts of the warm and temperate belts, which evidently should be included under this name But, though very much alike in their appearance, the shape and indumentation of the leaves, etc they show the greatest disparity in the dimensions of the several parts of the flowers We give here the extreme results of the dissections made

Calyx 2 6–4 5 mm Corolla 15 5–30 5 mm , the lobules 4–6 5 mm long Stamens 14–23 mm , the free part of the filaments 0 5–2 3 mm

As these lengths are in no way correlative, there is hardly a possibility of establishing on them well defined varieties The collections of Saer nos 15 and 184 may correspond to the var *pendulinum* (Jacq) O E Schulz, while this last author attributes the specimens collected by Johnston at El Valle, Margarita Island, to his var *mitanthum*

Cestrum Diasae Pittier, sp nov

Arbuscula e basi multiramea, ramis virgatis, teretibus, ramulisque brevibus villoso-tomentosis sparsissime glandulosis, foliis parvis coriaceis breviter petiolatis, petiolo marginato marginibus tomentosis, laminis ovalibus basi cuneatis in petiolo decurrentibus apice subobtusis subacutisve supra lucidis solute viridis plus minusve asperulo-villosulis venis primariis plerumque 7 impressis, subtus pallidioribus stellulato-tomentosis costa venisque prominentibus, pseudo-stipulis foliaceis, parvis, inflorescentia ramosa, floribunda, floribus in axillis spicatis, parvis, sessilibus vel breviter pedicellatis, bracteis parvis, obovato-oblongis, villosis, caducis, calyce infundibuliformi, 5-nerve, extus glanduloso-villoso, dentibus brevibus triangularibus apice subacutis penicillatis, corolla brevi, tubo infunibuliformi, extus glabro violaceo-flavescente, lobulis ovalibus imbricatis, extus atro-violaceis minutissime pubescentibus, marginibus introflexis, pallidioribus, minute tomentosis, staminibus tubo ad medio adnatis, filamentis laevibus, antheris ovato-cordatis, obtusis, glabris, ovario glabro, stylo laevi, stigmate, capitellato.

Arbuscula circa 1 m. alta Petiolus 4–7 mm longus, lamina 3 5–4.5 cm. longa, plus minusve 2 cm lata Pseudo-stipulae cum petiolo 1–1.5 mm. longo, circa 1 cm longae, 0 5 cm latae Ramuli floriferi 3 5–10 cm longi Flores 12 2 mm longi Calyx 4–5 mm longus, dentibus 0 5–0 8 mm longis. Corollae tubus 9 9 mm longus, lobuli 2 3 mm longi Staminum pars libera plus minusve 5 mm longa Pistillum circa 1 cm longum

MÉRIDA Misintí above Mucuchíes (3500 m) on dry slopes, flowers Feb 5, 1928 (*Pittier* 12919, type)

This species does not seem to have close affinities with any of those reported from the upper belt of the Andes I have named it in honor of my diligent assistant, Miss Margot Días, who has cleverly prepared all the dissections related to the Venezuelan species of *Cestrum* in our herbarium

CESTRUM TINCTORIUM Jacq Hort Schoenbr **3**: 45, *t 332*. 1798

The type of this species, which we have not seen, is from Caracas, where it was collected either by Jacquin himself or by Bredemeyer Schulz considers it as a simple variety of *C diurnum*, identical with his var *venenatum* (Mill) The characters given for the corolla in the original description, however, do not seem to favor this view Besides, since *C diurnum* does not exist in wild condition in Venezuela, it is unlikely that one of its varieties could have been collected near Caracas

CESTRUM POTALIAEFOLIUM Dunal in DC Prodr. **13**[1]: 638 1852

Collected somewhere in the Andes by Moritz (no 824, type), this imperfectly known shrub does not seem to have been seen again The quotation *Colombia*, in the Prodromus, is inaccurate, Moritz not having reached that country in his travels

Cestrum dubium Pittier, sp nov

Arbor parva (E Pittier), ramis flexuosis, glabris, parte defoliata cicatriculis foliorum delapsorum dense obtecta, juveniis angulosis, irregulariter sulcatis, foliis coriaceis, petiolatis, exstipulatis, glaberrimis, petiolo canaliculato, laminis oblongo-ellipticis, basi cuneatis, apice acutis, supra obscure viridis, costa venisque primariis 9–12 impressis, subtus pallidioribus, costa venisque prominentibus, inflorescentia terminali, pauciflora, spicis subcicinnatis, floribus purpureis, ebracteatis, pedicellatis, interdum (terminalibus) sessilibus, calyce tubuloso, tubo striato, glabro, dentibus irregularibus, triangularibus, apice puberulis, corolla infundibuliformi, glaberrima, lobulis oblongis, apice obtusiusculis, marginibus introflexis, staminibus ad medium tubo adnatis, filamentis laevibus, basi leviter incrassati, ovario styloque glabro

Petioli 0 6–1 cm longi, laminae 8–13 cm longae, 2 8–4 1 cm latae Inflorescentia 7 cm longa Flores circa 18 mm longi Pedicelli 0–5 mm longi Calyx circa 5 mm longus Corolla circa 17 mm longa, lobulis 5–6 mm. longis

FEDERAL DISTRICT Forests around Los Venados de Galipan, 1500–1800 m, above Caracas, flowers Oct 25, 1921 (*Emilio H Pittier* 166, type).

The only specimen at hand is very deficient and had a single complete

flower. It evidently should be placed near *C potaliaefolium* from which it is distinguished by the smaller, coriaceous leaves and the larger flowers

CESTRUM SALICIFOLIUM Jacq Hort. Schoenbr. 3: 42, *t 326* 1798.

Type from the vicinity of Caracas, where it was collected again by Humboldt and Bonpland. Our single specimen is from the State Miranda, where Allart found it at Quebrada de las Comadres, near Las Mostazas, 1100 m, at the headwaters of the Guayas River In the main, our plant agrees with the descriptions

Cestrum caloneurum Pittier sp nov

Arbor parva, ramis ramulisque virgatis, apice plus minusve pulverulento-pubescentibus, foliis coriaceis, glaberrimis, petiolatis, pseudo-stipulis munitis, petiolo pro genere longo, canaliculato, costaque nigrescente, laminis elliptico-lanceolatis, basi longe cuneatis, apice sensim acuminatis acutissimis, supra nigrescentibus costa impressa venis primariis circa 20 venulisque prominulis, subtus pallidioribus costa venisque prominentibus venulis prominulis, marginibus minute revolutis, pseudo-stipulis falcatis, glabris, persistentbus, floribus pedicellatis, bracteolatis, in panicula composita dispositis, cincinnis axillaribus, paucifloribus, rhachi dense cano-tomentello, pedicellis brevibus, interdum subnullis, bracteolis subulatis, caducis, calyce tubuloso-cupulato, tubo basi cano-puberulo, dentibus parvis, irregularibus, acutis, intus fulvo-pubescentibus, marginibus ciliatis, corolla virescente, tubo infundibuliformi, glabro, lobulis ovato-lanceolatis, obtusiusculis, marginibus introflexis, parce tomentellis, staminibus ad 1/2 tubo adnatis, filamentis basi leviter incrassata, interdum parcissime minutissimeque pilosulis, antheris subglobosis, stylo glabro, stigmate discoideo

Arbor 2–4 m alta Petioli 1 2–2 5 cm longi, laminae 7 5–18 cm longae, 3–6 cm latae Pseudo-stipulae 0 5–1 2 cm longae Panicula ad 15 cm longa, cincinni 2 5–7 cm longi Flores circa 2 2 cm longi Pedicelli 0–3 mm longi Calyx 10 mm longus Corollae tubus circa 1 7 mm longus, lobuli 3 5 mm. longi. Filamenta 6 5–7 mm longa Stylus circa 13 5 mm longus

ARAGUA Colonia Tovar, 1800–1900 m, in cloud-forests, flowers December 28, 1921 (*Pittier* 10045, type)

This species forms with *Cestrum calycosum* a group characterized by the larger dimensions of the calyx as compared with the corolla Also both are small trees, inhabiting the high forests of the coastal range of Venezuela But they differ entirely in the size, shape and consistence of the leaves which, besides, are exstipulate in *C calycosum* and provided with characteristic pseudo-stipules in *C caloneurum*

Cestrum calycosum Pittier, sp nov

Arbor parva ramis ramulisque flexuosis, glabris, lentiginosis, foliis magnis, glabris, membranaceis, longe petiolatis, exstipulatis, petiolis canaliculatis, laminis oblongo-ellipticis, utrinque attenuatis, basi cuneatis, apice acutissime breviterque acuminatis, supra laete viridibus, subtus parum pallidioribus, costa venisque primariis circa 18 tenuibus prominentibus, inflorescentia terminali, pauciflora, rhachi tomentello-puberulo, floribus sessilibus pedi-

lutis, pseudo-stipulis foliaceis, parvis, racemis axillaribus, sessilibus pedunculatisve, petiolis duplo-quintuplove longioribus rhachi lanuginoso, floribus sessilibus, glomeratis, congestis, stipulis parvis obovato-linearibus caducis suffultis, calyce poculiformi, striato, stellulato-languinoso, dentibus parvis acutis inaequalibus, corolla albida, tubo infundibuliformi, striato, glabro, in sicco sordide flavescente, lobulis ovalibus, apice subobtusis, in sicco fuscobadiis, marginibus introflexis tomentosinusculis, filamentis usque ad medium tubo adnatis, parte libera supra basin geniculato-tumida, basi plus minusve villosula, antheris ovato-rotundatis minutissime puberulis, ovario obovoideo, glabro, stylo glabro, filiforme, stigmate discoideo

Arbuscula circa 1 m alta Petioli 1 2–1 5 cm longi, laminae 11 5–22 cm longae, 3–10 cm latae Pseudo-stipulae 1–1 5 cm longae Racemi 3–6.5 cm longi Flores 13–15 mm longi Bracteolae 1–3 5 mm longae Calyx 3 5–5 5 mm longus Corolla 10 6–14 8 mm longa, lobulis 1 6–2 5 mm. longis Filamentorum pars libera 4 5–5 mm longa Pistillum 13 mm longum

TRUJILLO Mendoza, 1225 m, in shady places of the river flats and in coffee plantations; flowers January 19, 1928 (*Pittier* 12639) The type (*Moritz* 309) is wrongly given as from Colombia

Notwithstanding the much larger leaves and a few other rather slight discrepancies in the description, our specimens evidently correspond to Dunal's species under the above name It is not a species of the higher regions, but is to be looked for in the tierra templada In Mendoza it is known vernacularly as *guacharaquito* Its racemose inflorescences are striking and characteristic

CESTRUM NOCTURNUM L Sp Pl 1: 191 1753

FEDERAL DISTRICT Coromoto, 900–1000 m, valley of Camurí Grande on the coast east of La Guaira, in garden, flowers November 8, 1926 (*Pittier* 13029)—ESTADO ARAGUA La Trinidad de Maracay, 440 m, in bushes, flowers February 2, 1913 (*Pittier* 5797)

No 13029 is our latest acquisition in the genus and it agrees fairly well with Dunal's description, though less with O E Schulz's, with one exception, which may distinguish it as a special type The teeth are borne on the adnate part of the filament and not on the free part Several flowers have been examined and all show the same very large and obtuse teeth, inserted below the emergence of the filaments. At first, I felt inclined to separate this shrub as a distinct species and had even given it a name suggested by the relatively large size of the teeth But, on second thought, the name *nocturnum* was preserved, until the necessary comparison of specimens can be made The plant behaves exactly as described for *C nocturnum* When I collected my specimens, the corollas were odorless and closed tight as if still immature, but when I put them in the press at dusk, they were broadly open and emitted a strong, sweet scent

Specimens of our no 5797 we have not at hand and its identification, which, until verified, should be considered doubtful, was made at Washington, perhaps by myself

Cestrum bigibbosum Pittier, sp. nov.

Arbor parva, ramis ramulisque flexuosis, cortice griseo laevi tectis, foliis magnis, membranaceis, petiolatis, glaberrimis, exstipulatis, petiolo canaliculato, laminis elliptico-lanceolatis, basi acutis in petiolo decurrentibus, apice acuminatis tenuiter cuspidatis, supra laete viridis minutissime reticulatis, costa venisque primariis circa 12 impressis, venulis vix prominulis, subtus pallidioribus costa venisque prominentibus, inflorescentia terminali, bracteosa, depauperata, persistenti rhachi parce puberulo, bracteae lanceolatae, acuminatae, glabrae, floribus breve pedicellatis bracteolatis, bracteolis lineari-subulatis, pedicellisque puberulis, calyce tubuloso-infundibuliformi, plus minusve irregulariter 4–5-dentato, extus glabrato, dentibus parvis, obtusiusculis, apice puberulis, sinubus latis, corolla alba, tubo glabro basi tenui apice sensim ampliato, lobulis ovalibus oblongisve apice obtusis, marginibus anguste introflexis, dense puberulis, staminibus usque ad ⅓ tubo adnatis, filamentis glabris basi bigibbosis, antheris ovalibus, puberulis, pistillo glabro, stigmate capitato.

Arbor 2–4 m. alta. Petioli 1.6–2 cm. longi, laminae 15–28 cm. longae, 4–9 cm. latae. Bracteae 1–2.5 cm., bracteolae 1–3 mm. longae. Pedicelli circa 1 mm. longi. Flores circa 2 mm. longi. Calyx 5 mm. longus. Corollae tubus 1.5 mm. longus, lobuli 4–4.5 mm. longi. Filamenta 3 mm. longa. Pistillum 11 mm. longum.

FEDERAL DISTRICT: Between Aguacatal and Alto del Cogollal, 1500 m., valley of Puerto La Cruz, in dense forests, flowers February 18, 1921 (*Pittier* 9245, type).

Cestrum bigibbosum, which I have not been able to match with any other described species, is distinguished by its very large leaves, and its long-adnate filaments provided near the base of the free part with two well formed protuberances.

Cestrum amplum Pittier, sp. nov.

Arbuscula ramis crassis, erectis, atro-violaceis, glaberrimis, foliosis, foliis coriaceis petiolatis, plus minusve complicatis, glaberrimis, petiolo canaliculato, rugoso, in sicco nigrescente, laminis ovato-lanceolatis, basi cuneatis apice acutis subcuspidatisve, supra lucidis, costa impressa venis primariis 10–11 venulisque prominulis, subtus pallidioribus costa venisque primariis valde prominentibus venulis reticulatis prominulis, marginibus revolutis, stipulis foliaceis, parvis, inflorescentia paniculata, ampla, spicis axillaribus defoliatis densifloris, laxis, foliis subaequantibus, floribus pedicellatis subsessilibusve, pedicellis subcrassis calyce brevioribus apice bracteolatis, bracteis plus minusve foliaceis plerumque lineari-ellipticis, quam calyce saepe longioribus, nervo medio conspicuo, bracteolis lineari-filiformibus, brevibus, calyce tubuloso-poculiformi, tubo glabro plus minusve striato, dentibus irregularibus, plerumque angustis, duobus saepe ad medium adnatis, apice acutis, puberulis, corolla e basi angusta sensim dilatata, violacea, tubo glabro, lobulis ovatis ovato-ellipticisve, acutis, extus glabris, intus marginibusque introflexis fulvo-tomentellis, staminibus usque ad medium tubo adnatis, glabris, filamentis basi gibbosis, leviter incrassatis antheris suborbicularibus, ovario subovoideo, stylo elongato filiformi, stigma discoideo minutissime puberulo.

Arbuscula supra metralis. Petioli 0.6–1 cm. longi, laminae 9–11 cm. longae, 2.5–3.7 cm. latae. Stipulae 1.5–2.5 cm. longae. Panicula usque ad 30 cm. longa, basi 20 cm. lata, spicae 10 cm. longae vel breviores. Pedicelli

0–3 mm. longi. Bracteae 4–6 5 mm., bracteolae 1–3 mm longae. Calyx 7.3–7 7 mm. longus. Corolla 20–21 mm. longa, lobulis 4–5 mm. longis. Ovarium 1.2 mm. longum, 1 1 mm. diam ; stylus circa 2 cm. longus.

MÉRIDA Páramo de El Morro, 2800 m , flowers April 1, 1922 (*A. Jahn* 1075, type)

This species was identified at first with *Cestrum Lindeni* Dunal, but on further examination it was found that the leaves are on the whole shorter and narrower, the panicles larger, the flowers much longer, etc. Furthermore the type specimen of *C Lindeni* seems to have suggested to its describer a scandent shrub, while our *C. amplum* is without any doubt an erect plant, as seen by the specimens and also because a species with climbing habit would hardly be in its place among the low vegetation of a paramo.

CESTRUM MACROPHYLLUM Vent Choix des Pl. 18, *t 18*, 1803.

*Plant known hitherto only from Santo Domingo and Porto Rico, and re*ported by Rusby & Squires (no. 327) as part of their collections on the Lower Orinoco in 1896 This indication is doubtful

CESTRUM LINDENI Dunal in DC Prodr. 13[1]: 611. 1852.

The type was collected in the Andes of Trujillo, at 3000 m , by Linden (no 784). It differs from our *C. meridanum* mainly in its larger glabrous leaves and longer flowers I have not seen the plant

Cestrum meridanum Pittier, sp nov

Arbuscula ramis erectis densiuscule stellato-tomentosis; foliis coriaceis exstipulatis (?), petiolo brevi, sulcato, hirsuto, laminis ovalibus, basi cuneato-attenuatis apicem versus sensim angustatis acutiusculis, supra costa impressa puberula excepta primum parce stellulato-villosulis cito glabris sublucidis, crebre reticulatis venis primariis circa 12 venulisque prominulis, subtus parce stellulato-tomentosis costa venisque primariis dense rufescenti-tomentosis prominentibus, marginibus minute revolutis, inflorescentia e spicis brevibus in axillis subverticillatis, multifloribus composita, floribus tenuibus, sessilibus brevissime pedicellatisve, bracteoli-minutis, oblongis, basi attenuatis, obtusiusculis, calyce cyathiformi, striato, extus villoso-tomentosulo, dentibus brevibus subacutis, sinubus acutis; corolla infundibuliformi, virido-flavescente, glabra, tubo tenui, lobulis late ovatis obtusis, marginibus vix revolutis, staminibus usque ad $\frac{3}{4}$ tubo adnatis, glabris, filamentis supra basin geniculato-gibbosis, antheris flavis, ovario globoso, stylo glabro, stigmate capitellato, discoideo, minute puberulo

Arbuscula 0 80–1 20 m. alta Petioli 4–8 mm longi, laminae 7 5–9 cm. longae, 3–4 5 cm. latae. Bracteae 3–4 mm longae. Flores circa 16 mm longi. Calyx 5–6 mm longus Corolla 15-16 mm longa, lobulis circa 3 mm. longis Filamentorum pars libera 5–6 mm. longa Stylus 13 mm. longus

MÉRIDA· Vicinity of the city of Mérida, 1700 m , in bushes; flowers February 3, 1928 (*Pittier* 12858, type).

Belongs to the group of *C. Miersianum* but differs in its general appearance and especially in the shape and size of the flowers.

CESTRUM MIERSIANUM Wedd Chloris Andina 2: 97. 1857. (Descr. emend.)

Arbuscula ramis subcrassis virgatis ramulisque brevibus pulverulento-tomentosis, foliis exstipulatis, coriaceis, breviter petiolatis, petiolo villoso, stellato-tomentoso, laminis ovalibus lanceolatisve basi rotundatis, apice acutis subacutisve supra primum parce stellato-pilosulis in aetate glabratis, subtus pallidioribus plus minusve stellato-tomentosis tomento rufescente, floribus sessilibus raro breviter pedicellatis in ramulis brevibus axillaribus plus minusve defoliatis inflorescentiam terminalem valde multifloram congestamque efformantibus, calyce tubuloso, extus puberulo vel tomentello, tubo elongato dentibus brevibus obtusiusculis, corolla aequaliter tubuloso-infundibuliformi, tubo flavescente, glabro, lobulis ovatis, purpurascentibus, extus minute puberulis, intus marginibusque introflexis tomentellis, staminibus usque ad $\frac{3}{4}$ tubo adnatis, glabris, filamentorum parte libera basi crassiora gibbosa, pistillo capitellato, superne minutissime pilosulo

Arbuscula circa metralis Petiolus 4–6 mm longus, laminae 5–6 5 cm longae, 2.5–3 5 cm latae Flores 2 cm longi. calyx 5 8–7 4 mm. longus irregulariter dentatus, corolla 1 7–1 9 mm longa, lobulis 3–4 mm. longis Staminum pars libera 5 5–6 mm longa Stylus 1 5–1 7 mm longus

Type from Sierra Nevada de Santa Marta, 3300 m, Colombia (*Linden* 1615)

MÉRIDA: San Rafael de Mucuchíes, 3150 m, fl January 22, 1922 (*A. Jahn* 767).

The specimens in our herbarium agree in the main with Miers, succint description, the principal differences being the ovate rather than lanceolate leaves and the flower twice longer We know however that in this genus the the shape of the leaves is variable and on the studied specimens there are also a few flowers apparently fully developed and not exceeding the dimension given by Weddell Locally, the shrub is known as *uvito.*

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY

479TH MEETING

The 479th meeting of the Society was held in the Assembly Hall of the Cosmos Club, May 13, 1931, President O. E. MEINZER presiding

Section V of the Standing Rules of the Society was amended to read as follows.

V.—Annual Meeting and Election of Officers The order of procedure at the annual meeting shall be as follows.

1. Reading of the minutes of the last annual meeting
2. Presentation of the annual reports of the Secretaries.
3. Presentation of the annual report of the Treasurer
4. Announcement of the names of members who, having complied with Article III of these Standing Rules, are entitled to vote on the election of officers
5. Election of President
6. Election of two Vice-Presidents.
7. Election of Treasurer

8 *Election of two Secretaries.*
9 Election of five members-at-large of the Council.
10 Consideration of amendments to the Constitution.
11 Reading of the rough minutes of the meeting.

The election of officers shall be conducted as follows: The President shall annually appoint, at least four weeks before the Annual Meeting, a Committee of three active members, not members of the Council, whose duty it shall be to propose the names of one or more candidates for each office of the Society, the names to be presented at a meeting of the Society at least two weeks prior to the Annual Meeting Additional nominations for each office may be made from the floor at the Annual Meeting by an active member qualified to vote and the additional nominations shall be added to those proposed by the nominating committee, provided each such floor nomination be seconded by at least two other members present

Election shall be by written ballot in the order specified above The election shall be by written preferential ballot, counted by the Hare method, in accordance with the rules, given on pages 13 to 16 in Leaflet No. 11 of the Proportional Representation League, for the "exact" method of counting ballots (A copy of Leaflet No. 11 of the Proportional Representation League is made a part of this Section)

Regular program· W G PIERCE *Small folds produced by slumping in southeastern Montana* —In southeastern Montana, roughly 25 miles southwest of Miles City, three small asymmetrical folds were found Two of them are overthrust and slightly sheared They occur in the Tullock member of the Lance formation in an area where the beds are practically horizontal and from 25 to 100 miles from regions of known crustal compression In two of the three folds, thin coal seams are the principal beds involved in the folding The folding has taken place after consolidation and metamorphism of the coal to subbituminous rank, so that the folds can not be a phenomenon of sedimentation The outstanding features of the folds are. the folds do not persist with depth, they occur in the bottoms of valleys and only a few feet above the beds of creeks, alluvium is present a few feet above the folds and is not folded, the folds are parallel to the valleys in which they occur, the folds are not all overturned in the same direction, two are asymmetrical to the east, and the third is asymmetrical to the west

An unusual type of slump was noticed in the same area, a similar type of movement may have caused the small folds The dimensions or movement of the slump are 215 feet vertical and 600 feet horizontal The last part of the movement (85 feet exposed) was horizontal, on a bedding plane. Inasmuch as it has moved on a bedding plane, some thickness of strata was shoved up in front of the slump block. It is conceivable that the beds so moved would be shaped into small folds and thrusts

Two methods of folding by the movement of a slump block are possible· (1) By direct shoving against the strata normal to the bedding, as just indicated. (2) If considerable friction developed between the slump block and the underlying beds, the beds below the slump plane would be dragged into small folds and overthrusts (*Author's abstract*)

Discussed by Messrs BRIDGE, BEVAN, SEARS, GOLDMAN, and MISER

H A. MARMER *The determination of mean sea level.*—Sea level varies from day to day, from month to month and from year to year From one day to the next, sea level may vary by as much as a foot or more, while within a single year the altitude of sea level from two different days may differ by as

much as five feet The variation in sea level from month to month is in part periodic and in part non-periodic, and within a single year two determinations of monthly sea level may differ by a foot or more. Yearly determinations of sea level may show differences of a quarter of a foot or more

The determination of mean sea level thus involves two problems: (a) how long a series of observations is required to give an accurate determination of mean sea level? (b) how can sea level derived from a short series of observations be corrected to a mean value?

Since nineteen years is taken as constituting a full cycle in tidal work, this period of time is taken as giving a primary determination of mean sea level It is found, too, that nine years of observations will give a sufficiently accurate figure for mean sea level for most purposes Secondary determinations of mean sea level may be derived from observations covering a period of a month or more, by correcting the sea level from these short series of observations by comparison with simultaneous observations at some suitable station where a long series of observations is at hand In general it may be presumed that when corrected by suitable simultaneous observations, a month of observations will give mean sea level within 0 1 foot, a year will give it within 0.05 foot, while four years will give it within 0 02 foot (*Author's abstract.*)

Discussed by Messrs GILLULY, MATTHES, MEINZER, HEWETT, BRADLEY, and MENDENHALL

W. P WOODRING, and W S W KEW *Tertiary and Pleistocene deposits of the San Pedro Hills, California* —Metamorphic rocks of doubtful Jurassic age are the oldest rocks in the San Pedro Hills and the only ones that are not of Tertiary or Quaternary age Detrital deposits of middle Miocene age, with Temblor mollusks and Foraminifera of the *Valvulineria californica* zone, rest on the metamorphics Siliceous shales that are apparently of the same age as the lower part of the Modelo formation of the Santa Monica Mountains rest on the middle Miocene beds with gradational contact They are overlain, apparently without discontinuity, by the upper Miocene diatomite Resting disconformably on the diatomite are deposits of upper Miocene age consisting principally of radiolarian mudstone, which are overlain, probably disconformably, by foraminiferal silt referred to the lower Pliocene A period of folding, the results of which are visible in all parts of the hills, followed the deposition of these beds

The earliest Pleistocene formation, which fails to crop out on the water front and therefore was unknown to Arnold, embraces a calcareous facies and a detrital facies that finger into each other At one locality it is overlain by the silt that Arnold referred to the Pliocene, but elsewhere the lower part of the silt may be the equivalent of part of the calcareous formation The silt is succeeded by a granitic sand (Arnold's lower San Pedro) At San Pedro the contact is gradational, but on Deadman Island, which has been destroyed, it was disconformable Another period of folding, of mid-Pleistocene age, followed the deposition of this sand These three Pleistocene formations may not differ greatly in age

After this period of folding the hills were almost completely submerged and then rose intermittently. During this rise the conspicuous terraces were formed. Fossiliferous deposits are found on the lowest four or five of these terraces Those on the lowest one were called the upper San Pedro formation by Arnold. It is relatively much younger than the strongly deformed Pleistocene deposits. Along a mobile zone at the north edge of the

hills the youngest terrace and the deposits lying on it were deformed by renewed movements along earlier folds.

All the Pleistocene beds are marine and contain abundant fossils. The different faunas have different temperature facies, but it is not yet clear whether they can be linked with glacial and interglacial stages. (*Authors' abstract.*)

Discussed by Messrs. MENDENHALL, HESS, and RUBEY.

SCIENTIFIC NOTES AND NEWS

W C. MENDENHALL, a member of the ACADEMY, became Director of the Geological Survey December 21, 1931. His appointment by President Hoover is a promotion from within the service. Mr Mendenhall has been connected with the Geological Survey for 38 years, having been appointed assistant geologist in 1894 He was geologist in charge of ground-water investigations from 1908 to 1912 and chief of the land classification board of the Survey from 1912 until 1922, when he became Chief Geologist

The annual meetings of the Geological Society of America, the Mineralogical Society of America, and the Paleontological Society were held at Tulsa, Okla , during Convocation week. The officers for 1932 are as follows:

Geological Society of America.—R A. DALY, *President,* N. M. FENNEMAN, W. E WRATHER, R. S BASSLER (representing the Paleontological Society), and A N WINCHELL (representing the Mineralogical Society), *Vice-Presidents,* C P BERKEY, *Secretary,* E B MATHEWS, *Treasurer,* D F HEWETT, A C LANE, W J MEADE, W C MENDENHALL, SIDNEY POWERS, HEINRICH RIES, and F R VAN HORN, *Councilors*

Mineralogical Society of America —E. S DANA, *Honorary President,* A. N. WINCHELL, *President,* JOSEPH L. GILLSON, *Vice-President,* F R VAN HORN, *Secretary,* W T SCHALLER, *Treasurer;* WALTER F HUNT, *Editor,* C. S ROSS, P F KERR, W S BAYLEY, W J McCAUGHEY, and A H PHILLIPS, *Councilors*

Paleontological Society.—R S BASSLER, *President,* S B PLUMMER, E H SELLARDS, and C W GILMORE, *Vice-Presidents,* C O DUNBAR, *Treasurer,* WALTER GRANGER, *Editor*

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CHEMISTRY.—*Synthesis of a humus-nucleus, an important constituent of humus in soils, peats and composts.*[1] SELMAN A. WAKSMAN and K. R. N. IYER. (Communicated by C. THOM.)

The chemical nature and origin of humus in soil, in peat, in composts and in other natural substrates, where plant or animal residues are undergoing decomposition has attracted considerable attention during the last century and a half. This problem is not only of theoretical interest, but of great practical importance, since humus plays an important rôle in modifying the physical, chemical and biological properties of the soil, as well as in making the soil a favorable medium for the growth of cultivated plants.[2]

The problem of the origin and chemical nature of humus has been studied in this laboratory for more than 10 years. A number of papers have been already published, in which an attempt was made to study the process of transformation of the plant and animal residues which give origin to humus. Three general methods of approach were employed, namely:

(1) The decomposition of plant constituents of known chemical composition, such as cellulose, hemicelluloses, proteins, lignins, as well as various plant materials, such as straw, corn stalks, various leaves and needles of trees, etc., by pure and mixed cultures of microorganisms, under controlled laboratory conditions. The results obtained in these studies definitely established the fact that some of the plant constituents are decomposed very rapidly by microorganisms,

[1] Journal Series paper of the New Jersey Agricultural Experiment Station, Department of Soil Chemistry and Bacteriology Received December 12, 1931

[2] Summary papers dealing with the studies of the origin and chemical nature of humus were reported in Nat Acad Sci **11** 476–481. 1925, Soil Sci **22**. 123–162 1926; Cellulosechem **8**: 97–103 1927, Naturwiss **34**· 689–696 1927, Trans 2nd Comm. Intern Soc Soil Sci Budapest, *A* 172–197 1929; Amer Jour Sci **19**. 32–54 1930; Ztschr Pfl Düng Bodenk *A*, **19**: 1–31 1931

leaving no definite residue except the synthesized cell substance of the microörganisms, while other plant constituents are highly resistant to decomposition, especially under anaerobic conditions, and tend to accumulate, as shown by comparison with the total residual material.[3]

(2) The analysis of the organic matter or humus in the soil itself, including forest, peat and mineral soils. The results obtained substantiated markedly the findings in the first series of investigations, namely that the organic matter or humus of the soil comprises, (a) complexes of plant origin, which have resisted decomposition by microorganisms, although frequently considerably modified in their chemical nature, and (b) complexes synthesized by the microörganisms, during the process of decomposition. The first group consists largely of lignins and modified lignin complexes, and to a less extent of certain waxes and hemicelluloses, while the second group consists predominantly of proteins and certain hemicelluloses.[4]

(3) Synthetic processes, whereby complexes almost the same or quite similar to those found in the soil, peat and compost, or produced in the laboratory by decomposition of plant residues by microörganisms, have been synthesized. It is the latter phase of the investigations which will be reported here, since it completes in a way the cycle of studies and confirms the results obtained in the previous investigations by the other procedures.

Before reporting the results, however, it is necessary to define the terms commonly employed in the study of soil humus.[5] It has been recognized by the early students of the subject, such as Sprengel, Berzelius and others, that humus is not a homogeneous compound, but that it can be readily separated into two or more complexes.

[3] These studies have been described in a series of papers by Waksman, S A. and Heukelekian, H Jour Biol Chem 66. 323–342 1925, Fourth Intern Soil Sci Conf. Rome 3: 216–227 1924, Waksman, S A and Tenney, F G Soil Sci 22: 395–406 1926; 24: 275–283, 317–333 1927, 26. 155–171 1928; 28: 55–84, 315–340 1929, Waksman, S A and Stevens, K R Soil Sci 26. 113–137, 239–251 1928, Waksman, S A and Diehm, R A. Soil Sci 32: 73–96, 97–118, 119–140 1931, Waksman, S A and Gerretsen, F C Ecology, 12: 33–60 1931

[4] These studies have been published in a series of papers by Waksman, S A , Tenney, F. G and Stevens, K. R Ecology, 9: 126–144 1928, Waksman, S A and Stevens, K R Jour Amer Chem Soc 51: 1189–1196 1929, Soil Sci 30: 97–116 1930; Waksman, S A and Reuszer, H W Cellulosechem 11: 209–220 1930

[5] The term *humus* is used here to designate the soil organic matter as a whole, as well as the total organic matter in composts and peat which has undergone extensive decomposition as shown by a marked change in appearance, as well as in chemical composition, from the original material.

By using an alkali as the extraction agent, it was found that a part of the humus is soluble in this reagent and a part is insoluble. The soluble part was referred to as "humic acid," "ulmic acid," "crenic acid," etc., while the insoluble part was spoken of as "humin," "ulmin," "humus-coal," etc. In more recent investigations, the alkali-soluble part is referred to as "humic matter," "humus fraction," "pure humus," and the alkali-insoluble part as "non-humic matter" or "non-humus fraction," etc.

The existence of two different groups of complexes in soil humus, one of which forms a characteristic constituent of the humus and frequently makes up the larger part of it, has been established also by such reagents as dilute H_2O_2 solution, permanganate solution, hypochlorite solution, etc. That part of the humus which was acted upon by these oxidizing agents was believed to comprise the fraction which gives to the humus its specific, characteristic properties, the accumulation of this fraction was believed to be parallel with the extent of "humification" of the plant residues. The fact that this process of "humification" is accompanied by definite chemical changes in the residual plant constituents and possibly by the synthesis of new compounds has been also brought out by the use of acetyl bromide,[6] whereby it was shown that while fresh plant material is completely dissolved by this reagent, "humified" plant material leaves a considerable part unacted upon, this fraction, or so-called "pure humus," is presumably the same or about the same as that which was previously referred to as "humic acid," "humic matter," etc.

There is no doubt that the lignin in the humus originates largely from the plant residues, with possibly certain chemical modifications, such as loss of methoxyl groups,[7] etc. The proteins, however, have been largely synthesized through the activities of microorganisms. Although in the fresh plant residues the ratio of carbon to nitrogen is from 200 1 to 50.1, the humus in the soil shows a much narrower ratio of C:N, about 10 1, with considerable variation, depending on the nature of the organic residues, extent of decomposition, environmental conditions, etc. This great relative increase in nitrogen content can be explained only by the fact that the nitrogenous complexes in the humus are rendered resistant to further rapid decomposi-

[6] Karrer and Bodding-Wieger Helv Chem Acta, 6. 817 1923; Springer, U. Ztschr Pfl Düng. Bodenk *A*, 11: 313–359 1928, 22: 135–152 1931; Grosskopf, W Suddeut Forst Jagdz 1931, p 33–48

[7] See Fuchs, W. Die Chemie der Kohle J Springer, Berlin 1931

tion This is of considerable practical importance since it indicates that either the organic nitrogenous complexes in the humus are not of a protein nature or which is probably more correct that they are not in a free state otherwise they would decompose as readily as the plant and animal proteins ordinarily do

A detailed study of the chemical composition of the organic matter in forest soils and in inorganic soils brought out definitely the fact that humus or the organic matter of the soil which has undergone considerable decomposition consists largely of two chemical complexes namely lignin (40–45 per cent of the total humus) and of protein (30–35 per cent of the total humus) with smaller quantities of other substances especially hemicelluloses and to a less extent fats waxes and others In spite of the high protein content of the humus the nitrogen is not available to the growth of higher plants The possibility that we are dealing here with the formation of a tannin protein or a lignin protein complex[8] which would render the protein resistant to microbial attack has been suggested It has also been suggested[9] that the formation of the resistant humus complexes of the soil is due to the chemical interaction of carbohydrates with proteins

Among the other characteristic properties of humus to which attention may be called here is its high base-combining power which gives it a strong base exchange capacity a phenomenon very important in soil processes this property of humus exists only to a limited extent in the original plant material and is considerably greater than that of lignin

Since lignin and protein were found to make up a large percentage of the total constituents of humus and since these substances were found to give to humus its most characteristic properties it was considered important to begin the synthesis of humus with these two complexes By mixing lignin and protein in the same proportion that they exist in the soil organic matter and allowing the mixture to undergo decomposition by microörganisms in sand and solution media it was found that lignin had a depressive effect upon the decomposition of the protein as measured by the evolution of CO_2 and the formation of ammonia However this depression was only

[8] Dehéra n P P Ann Agron 14 97 133 1888 Hobson R P Thesis Univ London 1925 Moeller W Der Gerber No 1000 1003 1008 1916 (Chem Centrbl II 856 1916 I 30 440 1917) Jensen H L Jour Agr Sci 21 38–80 1931

[9] Ma llard L C Genèse des matières protéiques et des matières humiques Paris 1913

quantitative in nature, amounting to between twenty-five and fifty per cent of the total decomposition; in other words, in the presence of the lignin mixed mechanically with the protein, there was twenty-five to fifty per cent reduction in the amount of protein decomposed *in a given period of time.*

The protein was next dissolved in an alkali solution, and mixed with three to five volumes of a similar solution of lignin; the reaction of the mixture of the two solutions was then adjusted to a pH of about 4.5, where a precipitate was formed. The precipitate was now washed, dried and allowed to decompose. The complex underwent only a very limited decomposition, not much more than the "humic acid" obtained from soil or peat, by extraction with alkali and precipitation by acid.

By introducing into the precipitating mixture bases, especially calcium, magnesium, iron, all of which are important in soil processes, and allowing precipitation to take place at a pH of about 7.0, a complex was obtained which showed all the characteristic properties of the important constituents of soil humus, formerly referred to as "humic acid." Both in appearance, and in their chemical, physico-chemical and biological properties, the preparations were similar to the various "humic acid" or "α-humus" preparations that can be obtained from different soils.

The lignin used for this purpose was prepared by extracting straw, previously treated with water and hot dilute mineral acid, with 4 per cent NaOH solution under 15 pounds pressure; the lignin was precipitated with hydrochloric acid, and washed free from chlorides; the lignin thus prepared contained only traces of ash, nitrogen and carbohydrates. As a source of protein, casein prepared after Hammersten and gliadin were employed. Five parts of lignin and one part of casein were separately dissolved in hot alkali solutions, the solutions were well mixed and the reaction adjusted by hydrochloric acid to pH 7.0, on adding an excess of $CaCl_2$ solution, the complex was precipitated; it was then washed free from chlorides. In a similar manner magnesium and iron compounds of the ligno-proteinates were prepared. The chemical composition of the "synthesized humus" thus prepared in the laboratory and the "natural humus" or the "humic acid" isolated from the soil are nearly the same and their behavior to different chemical reagents is alike.

The decomposition of these ligno-proteinates was tested in solution and in sand media, inoculated with pure and mixed cultures of soil

microörganisms. Their decomposition was no more rapid than that of an equivalent amount of soil humus, prepared from peat or from soil (so-called "humic acid" or "α-fraction of humus").

These "synthesized humus" complexes were found to have a highly beneficial effect upon soil microbiological processes, as shown by their influence upon the decomposition of dextrose by soil bacteria, growth and fixation of nitrogen by Azotobacter (especially the iron complex), decomposition of cellulose by bacteria and fungi, etc. However, although containing about 2 per cent of nitrogen, the complexes cannot be used as sources of nitrogen by the various soil organisms. The proteins have become "lignified" and in this condition cannot be readily attacked by the common soil microorganisms.

Chemically and in their base-exchange capacity the "artificial-humus" complexes behave exactly in the same manner as that part of the soil humus which is soluble in alkalies and is precipitated from the alkali solution by acid, namely the "humic acids" or the "α-humus."

The authors believe that they have succeeded in synthesizing from plant constituents, in the laboratory, by simple chemical treatment, a complex which has the characteristic properties of the most important constituent of the soil humus. The most appropriate name for this complex would have been "synthetic humus," which it actually is, however, since this term has been so much used and misused historically for preparations which have nothing to do with the soil humus, such as the dark-colored material obtained on treating various sugars and other carbohydrates with sulfuric and hydrochloric acids, this term will be avoided It is proposed to apply to these complexes the name *humus-nucleus*, since they form the nucleus of the humus in soils, peats and composts, making up 50 to 80 per cent of these materials, depending on their nature and degree of decomposition.

The mechanism of formation of the *humus-nucleus* in soil can be schematically presented as follows

When plant residues are introduced into the soil, rapid decomposition will set in, under favorable conditions of temperature and moisture, immediately. However, the plant material does not decompose as a whole, some of the constituents, especially the water-soluble substances, such as the sugars and amino acids, are attacked immediately by a large number of fungi and bacteria; these are followed soon by the decomposition of the starches, proteins, certain hemicelluloses (pentosans, mannans) and the true cellulose; some of the

constituents, like the sugars, starches and proteins are attacked by a great variety of organisms, while others, like the cellulose, are decomposed only by certain specific fungi and bacteria, some of which are highly selective in nature, the lignin is, of the more abundant plant constituents, most resistant to decomposition, especially under anaerobic conditions. These decomposition processes are accompanied by continuous synthesis of microbial cell substance, due to the rapid multiplication of the bacteria and fungi decomposing the plant constituents, to the rapid development of the protozoa, nematodes and other invertebrates feeding upon the bacteria and the fungi as well as upon some of the undigested or partly digested plant residues, and finally to the development of various microörganisms feeding upon the products of the metabolism of the other organisms, such as the algae, autotrophic bacteria, etc. These synthetic processes result in the building up of considerable quantities of microbial cell substance which is rich in proteins (10 to 60 per cent) and in certain hemicelluloses (microbial gums, slimes). In view of the fact that this cell substance is considerably richer in nitrogen than the original plant residues (most of the plant residues containing only 1.2 to 6 per cent protein), there is a continuous accumulation of the protein with the advance of the decomposition of the plant residues. This protein does not remain in a free state or in the microbial cell substance, but with the breakdown of the latter by other microörganisms, the protein combines with the lignins and the modified lignins of the plant residues, liberated as a result of the decomposition of the cellulose, to give rise to ligno-protein complexes; this renders the proteins resistant to rapid decomposition. These complexes are acid in nature, and in the absence of bases in the soil or in the plant residues, they make the humus acid, as in the case of the upper layers of organic matter in the raw-humus forest soils. However, in the presence of bases, especially calcium and magnesium, they interact with these to give rise to calcium and magnesium ligno-proteinates, which are neutral in reaction or only slightly acid With an increase in the formation of the ligno-proteinates, especially their basic compounds (Ca, Mg, Fe, etc.), there is a darkening in the color of the mass undergoing decomposition, this dark color is a characteristic property of the ligno-proteinates, depending on the degree of their oxidation, nature of bases, etc.

The ligno-proteinates form the most essential constituents of the soil humus or the *nucleus of the humus*. They are accompanied by various other organic complexes, of plant, animal and microbial

origin, undecomposed or in the process of decomposition. Here belong certain hemicelluloses, especially pectins and other uronic acid complexes, a small amount of cellulose (especially in the surface layers of forest soil), fats, waxes, corky substances, various organic acids, alcohols in a free or combined state, etc.

The total organic matter of the soil, or the soil humus, can thus be divided into two distinct groups:

1. The *humus-nucleus* consisting of ligno-proteinates, combined with bases, thus giving H-ligno-proteinate, Ca-ligno-proteinate, Fe-ligno-proteinate, Al-ligno-proteinate, and probably also with silicates and phosphates, to form organic-inorganic complexes, which give to the soil its characteristic colloidal properties. These ligno-proteinates are probably combined also with certain other organic complexes, such as the hemicelluloses. This is the fraction which has formerly been referred to as "humus," "humic acid," "ulmic acid," "humic bodies," etc. It is the mobile fraction of the soil organic matter (which is probably active in removing the bases of the surface soil layer in the process of podsolization). It is the resistant fraction, which immobilizes the soil nitrogen. It is the "humified" fraction, which gives to the soil its characteristic color and organic colloidal properties.

2. The remaining constituents of the humus, comprising cellulose, hemicelluloses, starches, fats, waxes, etc. This fraction consists largely of plant residues in the active stages of decomposition and is particularly abundant in composts, in the surface layers of forest soils, in highmoor peats, etc., while it is low in those natural substrates where the plant organic matter has undergone considerable decomposition, such as inorganic soils, lowmoor and sedimentary peats, and may even disappear in the course of time, as is possibly the case of Cassel Brown and coal. This fraction has been usually referred to as "humin" (although under this term as well certain of the ligno-protein complexes might have been included), "non-humic bodies," etc., as well as "crenic," "apocrenic," "fulvic," "humal" and other so-called acids.

In view of the fact that the ligno-proteinates, or the *humus-nucleus*, tend to have a definite ratio between the lignin and the protein, we would also expect a more or less definite ratio between the carbon and nitrogen in the complex, actually the preparations synthesized and isolated from the soil contain about 3 per cent nitrogen, which gives about 81 per cent lignin and 19 per cent protein. By allowing 62 per cent for the carbon content of the lignin and 50 per cent for the

carbon content of the protein, and four parts of lignin to one part of protein the complex should contain theoretically 59.6 per cent carbon. However, the presence in the soil humus of other organic complexes, of a lower carbon content, will reduce this percentage of the carbon in the humus, especially in the case of the surface layers of forest soils, composts, highmoor peats, which contain considerable quantities of cellulose, hemicelluloses and other complexes, of a lower carbon content. These ligno-protein complexes are not absolutely resistant to decomposition, but can be attacked by certain organisms, such as the edible mushroom and probably various other higher fungi, such as the tree-forming mycorrhiza. The correlation between the two groups of complexes in the humus need not, therefore, hold true for all forms of humus. One can readily imagine that under certain conditions, as in certain processes of podsolization, some of the compounds, such as the proteins (possibly due to the destruction of the lignins by certain specific fungi), should be removed more readily than the others, as a result of which we may find in the accumulation horizon organic complexes of a higher nitrogen content. Under other conditions, as in highmoor peats, where the accumulation of nitrogen complexes is only very limited, the humus-nucleus may be much less abundant than the remaining part of the humus, this nucleus, if formed at all may be poorer in protein than the nucleus in soil or lowmoor peats

While lignin itself has only a very low base-exchange capacity (about 6 5 M. E. per 100 gm.), the ligno-protein complexes were found to possess a very high capacity for base absorption and exchange (between 120 and 130 M E.). Lignin no doubt undergoes, in the process of decomposition of plant residues, certain processes of oxidation and de-methoxylation. In this state, it interacts with the proteins, largely synthesized through the activities of the microorganisms The nature of the complex formation is still problematical. Several possibilities present themselves. One is between the NH_2 groups of the protein molecule, reacting with a carbonyl group, either ketonic or aldehydic, in the lignin molecule, as shown by the following reaction [10]

$$\underset{\textit{Lignin}}{C_{52}H_{46}O_{10}\,(OCH_3)\cdot(COOH)\cdot(OH)_4\cdot CO} + \underset{\textit{Protein}}{H_2N\ R\cdot COOH} \rightarrow$$

$$C_{52}H_{46}O_{10}(OCH_3)\ (COOH)\ (OH)_4\cdot C = HN\cdot R\cdot COOH + H_2O$$

Humus-nucleus

[10] This reaction has been suggested by Dr M Phillips of the Bureau of Chemistry and Soils

A compound of this type would be quite stable, especially to hydrolytic agents. It also explains the high base exchange capacity of the ligno-protein complexes. The protein is an amphoteric substance and, when the NH_2 group is tied up by combining with a carbonyl group of the lignin molecule, the acidic character of the COOH groups becomes prominent, which results in a decided increase in the base-exchange capacity of the complex. The COOH groups of the lignin molecule may also become more reactive with bases, as a result of the complex formation. The possibility of interaction of the NH_2 groups with the phenolic OH groups of the lignin or the acidic COOH groups may also be suggested, although the complexes of this type would be less stable than is the case of the "humus-nucleus."

The synthesis of artificial humus, or a lignin-protein complex, offers numerous possibilities for further study, which would lead to the elucidation of the chemical nature of soil humus and its rôle in soil processes Some possibilities may be briefly outlined as follows. 1. The nature of the replaceable hydrogen, since, aside from the fact that the original lignin has a low base-exchange capacity, the complex formed seems to possess a higher capacity than can be accounted for by the COOH group of the protein molecule 2. The possibility of combining varying numbers of protein molecules with a given number of lignin molecules, thus accounting for the varying nitrogen content of the soil humus, formed in different soils, at different depths and under different climatic conditions. 3. The possibility of certain bases, like the sesquioxides, of forming compounds possessing definite amphoteric properties. 4. The possibility of using this complex for attaching molecules of other compounds, especially the hemicelluloses, which, due to the uronic acid complexes, possess base-combining properties. 5. The possibility of building up organic-inorganic complexes, which may account for a number of soil reactions, such as availability of certain soil minerals, especially iron, phosphorus and potassium, for plant nutrition, etc.

PHYSICAL GEOGRAPHY.—*The classification of peat soils.*[1] A. P. DACHNOWSKI-STOKES, U. S. Bureau of Chemistry and Soils.

I

It need scarcely be pointed out that classifications are subjective concepts. They are more or less adequate means by which objects under investigation, whether peat soils or other materials, are arranged in an orderly fashion.

[1] Received December 7, 1931.

Classification has three purposes which though distinct, can not well be dissociated. It may be employed (1) to facilitate identification and differentiation of the objects classified, (2) to show relationships and to organize our knowledge concerning the particular objects, and (3) to serve various practical interests, such as agriculture and industry. Thus it happens that on seeking a definition and classification of peat soils great difficulty is encountered in finding a nomenclature or system that avoids including more than was intended, or leaving out something which should be taken in.

In the popular mind peat soils are still classed as peat and muck. The differences are based either on a simple character or on very simple combinations of characters. Arrangement according to any readily perceived, simple property is comparatively easy and is the first to suggest itself.

The first classifications of peat soils made by scientists were based on color, weight, ash content, reaction, and other properties which are still depended on as means of identification. Those likenesses among peat and muck materials which are due to their possession in common of some color, weight, or calorific value were believed to coexist with other properties and hence peat soils were placed together which later proved to be unlike in their essential natures

In recent years it has become obvious that the arrangement of peat and muck according to combinations of properties, which though fundamental are not conspicuous, requires analyses based on considerable field investigation and laboratory work. The grouping of complex objects such as peat soils can reach its complete form only by slow steps and after analysis has made more progress As the pedographic knowledge of regional peat areas increases it becomes possible to ascertain which properties of peat soils are most characteristic, and to make groups of the members that have many properties in common. The ultimate arrangement will serve not only to identify peat soils completely and express the greatest information regarding their character in any of the major groups but it will also permit the prediction of a great number of facts about deposits of peat in other countries and by so doing reveal the precise correspondence between "our concepts and the reality."

II

The writer's own investigations illustrate well the phases through which classification of peat soils is passing. In early attempts at some systematic manner, all kinds of peat were separated by conspicuous

physical characteristics into three classes comprising woody, fibrous, and sedimentary peats. The limits were narrower and different otherwise from those assigned to them by earlier observers. In successively later attempts more regard was paid to botanic composition coordinated with the simplest analytical methods such as those employed for crops and feeding stuffs, for determining a number of chemical complexes which represent essential but generally inconspicuous changes in the transformation of organic materials.

Passing through various modifications in which the arrangement was dictated by the viewpoint of degree of decomposition and the recognition of conspicuous morphological features in the inherent structure of peat deposits, another order of facts came to be recognized,—those of development

Ecological studies led to an arrangement of peat deposits into groups and subgroups in such a way as to display the developmental differences produced by climate, by natural vegetation, and by the larger topographic diversities existing among the several great groups of peat areas in this country. The fundamental differences in the development of peat deposits—that is, in origin, sequence of parent peat layers, and the varying stages of profile development—did not admit of being placed in a linear order, but only in an arrangement perhaps not unlike that regarded as a branching of clusters. If it be supposed that dots representing type profiles form clusters expressing genera and species, the names of which it is impracticable to insert here, and if the successively larger groups and their general distribution constitute orders in the subkingdom of organic soils, an approximate idea will be formed of some of the facts that should be included in a classification of peat soils. The relationships of these diverging groups cannot, however, be expressed on a flat surface, or in space of three dimensions, but must also include the more significant contrasts ascribed to time. Though under present conditions it seems too soon to attempt a definite scheme of classifying peat soils and their relationships, yet it has seemed that an outline of a tentative scheme may be ventured presenting in a general way such relationships as they are now conceived. In a forthcoming publication a scheme will be described dealing with American peat deposits, their characteristic profiles and classification. In this classification is exhibited a conclusion of basic significance, namely that the structural profile features by which members of one group differ from those of another, have developed under dominating influences active in past periods; they are largely

products of forces and changes in environmental conditions that operated long before the present period. In the present paper an illustration will be given to indicate the nature of the conditions which caused such differences in former times, and the character of the peat soils that developed in various layers of the profile under the influence of the major soil-making processes.

III

Facts which illustrate the development of peat areas and their soils, and the influence of surrounding conditions, are abundant and familiar to many. The restriction of different kinds of vegetation to their particular environment is the broadest, basic fact of ecology and of geographic distribution. There are extensive plant communities that are respectively aquatic or amphibious, and others that are confined to the land. Besides hydrographic and topographic limitations there are the familiar limitations made by climate. These factors vary from place to place and from time to time, producing by their effects an extension or restriction on vegetation and on soil formation.

To the limiting environmental factors must be added others imposed by the reciprocal relations of plant associations, either competing, directly destructive to one another, or coacting in what is now known as succession and the development of the climax community. Plant associations are held together in a web of relations, and any considerable modification which one aggregation of plants undergoes acts indirectly on others, eventually changing the conditions of nearly all other communities associated with them. In the development of peat deposits from extreme conditions in the water relation, whether building up a substratum from a lake bottom or from land or bare rock, the plant communities involved and their habitat change more or less rapidly. Each community of plants contributes certain effects to this developmental process; each modifies its own environment in the quantity of light and heat, the movement of air, water, and salts, the activity of soil microorganisms, and hence its own chances of permanency. Thus takes place a succession in which differently constituted plant communities replace one another, each forming a layer of peat with characteristic soil properties, each contributing modifications to the development of an organic aggregate, until the conditions of drainage, aeration, and the activity of microorganisms become stable enough to produce a relatively permanent or climax stage of peat soil

and vegetation cover. It is logical to assume that each climax vegetation should be and probably is a center of organic soil production, characteristic of that particular region and its vegetation.

Peat areas of the type of profile development representing the uniserial succession from lakes and ponds have been described in many publications. They may be found as minor or intermediate successional stages in adjoining regions and some of the earlier stages may have a wide distribution in regions characterized by a different vegetation climax. But the accumulation of evidence has brought the conviction that many peat profiles are made up of layers marked off from one another by great morphological contrasts, and that the strongest divergences in structural characteristics are products of changes in climate and plant migration.

The progress of peat investigations has shown with increasing force the extent to which past environmental changes have contributed to the development and distribution of characteristic peat soils as expressed in the profile during the course of its formation in space and time. It was shown elsewhere that departures from the general, uni-serial development of peat deposits may include abnormal and to a greater or less extent complex profiles. In fact, development may have taken place repeatedly in the same direction, and in no connection with the present environmental conditions. A classification of peat soils so comprehensive as to stimulate investigation into every feature of peat deposits should, therefore, include information not only regarding changes that occur now or may occur in the near future, but also the characteristic materials that have been produced in the distant past. It should include data on the nature of the processes recorded in the history of the profile, and bring out the contrasts and important properties of the respective products that developed from the parent material at earlier times.

IV

In all peat deposits, layers of buried plant remains are found in greater or less abundance which were exposed in varying degrees to the influence of soil-making processes and to partial or extensive decomposition. The differences between layers of peat are, speaking generally, small and continuous where the main environmental condition, notably the quantity and quality of the ground water, was a continuous factor. Leaving out of consideration those paralellisms among trends of development which characterize type profiles belong-

ing to each group or subgroup, the occurrence of morphological differences is greater where the factors of a major process that caused such differences were more dynamic and effective. It will necessarily happen that changes in local conditions to which a type has been subjected directly or indirectly will give no evidence of modifications that have generic value; the transitions will be less numerous in peat areas which in the past were less variously conditioned. The type profile may be defined, therefore, as a unit the boundaries of which include transitions and variations in color, thickness, or reaction, but not in the number, sequence, and character of the layers. The latter express the direction as well as the stage of profile development, and they show the extent and the kinds of effects produced by the changes in environmental forces which influenced decomposition The contrasts in parent materials, degree of decomposition, and the character of the resulting peat soils will be comparatively large and abrupt where the changes in environment were correspondingly wide or sudden or where modifications of the parent material took place more or less completely as a result of long-continued soil-forming processes.

Instructive examples of profiles showing remarkable changes in the course of their development are furnished by deposits of peat in northern Minnesota, Wisconsin, and Michigan. The type profile described below is located near Three Lakes, Oneida County, Wisconsin. The following brief summary of its morphological features and history of development is intended to show the problems which a classification of peat soils must solve, and to explain structural characteristics that are otherwise unaccountable.

V

In Menominee County, Michigan, in Oneida, Bayfield, and Douglas Counties, Wisconsin, and in St. Louis, Lake of the Woods, and Roseau Counties, Minnesota, are areas whose profile consists of five separate layers. In the order of sequence, from below upward, they are composed of reed-sedge peat, followed by woody peat, and a surface layer of sphagnum-moss peat. Of chief interest is the presence of a second and well defined younger layer of woody peat which separates the surface layer of moss peat into two distinct parts.

The basal layer of reed and sedge peat is generally yellowish brown in color, poorly decomposed and coarsely fibrous to felty matted, indicating that the deposit developed from a marsh stage of vegetation under conditions of water level at or near the surface. The flat-

pressed rhizomes represent largely the well preserved cuticular tissues of reeds and a variety of sedges. The thickness of the layer and the lack of marked differences in respect to degree of decomposition and color show that the layer was not impoverished and not exposed to contrasts in weathering, leaching, or evaporation and the concentration of salts. At that time reed marshes were spreading over wide sections of this country. They continued to persist as dominant communities for a long period, and hence a deposit was formed consisting essentially of reed-sedge peat to a height approximating that to which ground waters rose in the capillary spaces. Differences in the character of the peat soils which may have developed from the parent material of this extensive unit of natural vegetation are much obscured by the varying botanical composition of the whole layer

At a later period various portions of the ancient marshes in the Great Lakes region became wooded with thickets of deciduous shrubs, finally culminating in a swamp forest of mixed conifers and hardwoods. Cedar and tamarack were prominent with a small percentage of deciduous trees, both as a mosaic of pure stands and a general mixture which included an undergrowth of herbaceous plants. The properties of that portion of the parent reed peat in contact with the woody material were almost entirely changed; reed muck of varying depth merged with the dark-brown, partly granular woody material and ligneous fragments derived from the swamp forest.

With such evidence the assumption is not altogether unwarranted that the reed muck in contact with the wood peat soil reflects a fluctuating, lowered water level, better drainage and aeration. The penetration of woody roots into the reed peat, the shading of the organic material by a forest crown, and the accumulation of granular residue, stumps of trees, fallen timber, branches, bits of fungal mycelium, and the litter of needles, scales, and cones indicate the diversity of growth forms of this stage of vegetation. They reveal differences in physical conditions and disclose the presence of aerobic microorganisms and wood-destroying fungi causing decay.

How long ago the miscellaneous plant remains of the ancient forest were exposed to an environment so radically different in soil-forming conditions can not be determined precisely. Doubtless the process was gradual and continuous, removing effectively the more soluble organic complexes and developing the woody residue; but there may have been times when the disintegration of ligneous tissues was more rapid than at others.

One more striking fact must here be set down. It is noteworthy that trees of pine, tamarack, cedar, and several deciduous species of large diameter occupied at one time a section of the Great Lakes region in which today only dwarfed spruce dominate. It is well known to ecologists that a stage of mixed conifer and hardwood forest was more extensive several thousand years ago than today. Its geographical position is recorded by plant remains found well within the limits of the boreal region and in peat deposits of southeastern Canada. They suggest a period marked by a warm and generally dry climate and by the movement northward of deciduous forests.

As pointed out above, the layer superimposed upon the woody peat soil is yellowish-brown, spongy-fibrous, poorly decomposed moss peat, grading to reddish-brown partly decomposed material derived from several species of Sphagnum. The penetration of woody underground stems from shrubby heaths is chiefly along shallow depths extending from 4 to 7 inches below the surface. Stumps of small spruce trees are also found at this level. With the exception of the dome-shaped deposits along the northeastern coast of Maine and the slightly curved areas near Corona and Floodwood, Minnesota, the surface layer of moss peat in the Great Lakes region is rarely three feet in thickness. The evidence so far secured strongly suggests that this region may have experienced the effects of a marked shifting of ice movement in northern Canada, and that a great change in temperature and humidity affected the northern portion of the Great Lakes Basin. The southward swing of colder conditions was accompanied by a southward movement of Sphagnum mosses, followed by an arctic floral element, by heaths and spruce. That such disturbances affected also human migrations is a fact to be found recorded in history. The dependence of Sphagnum mosses upon cool and moist atmospheric conditions, their habit of growth, and the capacity of moss peat for taking up and holding large quantities of precipitation water, give these plant remains a unique quality toward checking aeration, bacterial activity and decomposition, and intensifying an acid reaction The rôle of Sphagnum mosses in the invasion of reed and sedge marshes and in the ultimate extinction and burying of forests has been described frequently. As a plant community Sphagnum mosses and their associates had no relation, either floristic or successional, to the swamp forest of that earlier period Even today they stand in great contrast as outposts to the south, outside the limit of their present climax in the boreal region. The layer of moss peat points, therefore, to a

change to colder and more humid conditions, to leaching, the loss of nutrients, and the general impoverishment of soils and vegetation.

It may be well to note briefly that the second and younger layer of woody peat soil represents a mixed coniferous forest of possibly parallel nature to the "Grenzhorizont" of European highmoors. The occurrence of dark-colored woody material in an advanced degree of decomposition between layers of comparatively well preserved moss peat is a striking morphological fact not explicable as a result of the forces that led to the accumulation of moss peat. It points to a shift of climatic conditions and to a readvance of mixed conifer forests and deciduous trees from the south and east. It involves a process of decomposition whereby woody plant remains were converted into residual products that were left in place. It reflects environmental conditions which were temporarily much less cold and humid as judged by the vegetation that formed the intervening, impoverished layers of moss peat.

There is little to be said concerning the trend of peat soil formation in the Great Lakes today. It represents an approach toward conditions which displace and exclude Sphagnum mosses and their associates, but favor the dominance of a vegetation cover which finds its extreme expression in a mixed conifer swamp forest. These facts are evidence pointing toward an oncoming period of desiccation and a renewed tendency to the development of forest soil. It is not unreasonable, therefore, to regard the modern trend in the climate of North America as characterized by irregular fluctuations, and as passing once more to a warmer and generally drier climate than was that of a few thousand years ago.

Thus one is brought to realize that the development of peat profiles is an orderly thing. Especially will this be the case where profiles of individual deposits have become relatively definite and where shifts in environmental conditions were accompanied by a corresponding complexity in structural features The resulting differences in the character of peat soils may in such cases become so pronounced as to greatly obscure the relation to the parent material

With due allowance for the difficulties encountered in reconstructing past environmental conditions, it is now generally recognized that peat investigations are the best approach to a knowledge of the nature of past changes in environment This implies that they tend likewise to show the effects of the major environmental processes in developing peat soils of widely differing character. Doubtless an exhaustive study of profiles would disclose that the soil-making processes of former

periods bear to our present contrasting conditions a corresponding relationship.

But how past climatic and other dominating factors have worked in the production of peat soils cannot be thus accounted for. This is to be determined mainly by more detailed investigations of peat profiles and the chemical constituents of peat soils coordinated with more adequate knowledge concerning the microörganisms capable of bringing about decomposition.

BOTANY.—*Five new species of* Bomarea *from Peru.*[1] ELLSWORTH P. KILLIP, U. S National Museum.

In the course of recent studies which I have been making of Peruvian material of the amaryllidaceous genus *Bomarea*, five new species were found to be represented. Descriptions of these follow.

Bomarea caudata Killip, sp nov.

Caulis volubilis glaberrimus; folia oblongo-lanceolata, abrupte acuminata basi rotundata membranacea supra glabra subtus in nervis primariis pilis crispatis hyalinis sparse hirsuta, bracteae lanceolatae et setaceae; umbella ca 18-radiata dense rufo-tomentosa; ovarium turbinatum dense rufo-tomentosum, sepala oblanceolata longe corniculata coccinea, petala sepala subaequantia spathulata in costa rufo-tomentella viridia, brunneo-maculata.

Vine, stem subangulate, glabrous, petioles up to 8 mm long, strongly corrugate at margin, leaves oblong-lanceolate, 7 to 10 cm long, 2 5 to 3 5 cm wide, abruptly acuminate at apex, rounded at base, membranous, glabrous above, sparingly hirsute with long crispate hyaline hairs on the principal nerves beneath, the nerves about 1 mm apart, unequally prominent, bracts of two forms, the outer lanceolate, 1 5 cm long, 6 mm wide, the inner setaceous, 1 cm long, umbel about 18-rayed, the rays 2 5 to 3 cm long, straight, densely rufo-tomentose, ebracteolate, ovary turbinate, densely rufo-tomentose, sepals oblanceolate, about 2 cm long, 7 to 8 mm wide, dorsally corniculate near apex (horn 5 to 6 mm long), sparingly rufo-pilosulous or glabrous, blood-red, petals spatulate, subequal to sepals, barely 1 5 mm wide in lower half, 5 to 6 mm. wide toward apex, rufo-tomentellous on midrib dorsally, otherwise glabrous, green, brown-spotted, stamens 2 to 2 5 cm long, the anthers ovate, 3 5 mm long, 2 mm. wide

Type in the herbarium of the Field Museum of Natural History, no. 562,472, collected in evergreen forest, Choimacota Valley, Province of Huanta, Department of Ayacucho, Peru, altitude 2,800 to 2,900 meters, February 28 to March 10, 1926, by A Weberbauer (no 7559)

The only other species of *Eubomarea* with long-horned sepals are quite different. *Bomarea cornigera* is glabrous throughout and has leaves not over 1 5 cm. wide and an umbel of only 1 to 4 flowers *Bomarea cornuta* has

[1] Published by permission of the Secretary of the Smithsonian Institution Received December 24, 1931

forked umbel rays, and is closely related to *B. ovata*. The proposed species is probably allied to *B. purpurea*, from which it differs in the horned, proportionately broader sepals and a scantier indument on the under surface of the leaves.

Bomarea nematocaulon Killip, sp. nov

Caulis tenuis subteres glaber ad apicem glanduloso-puberulus foliosus; folia anguste oblonga vel lanceolato-oblonga, apice acuta et crassa, brevipetiolata parum revoluta 9-15-nervia supra glabra subtus in nervis pilis crispatis hyalinis strigillosa, bracteae 3-4 foliis similes; umbellae 2-3-radiatae, radiis glanduloso-puberulis 1-2-furcatis, bracteolis lineari-lanceolatis acuminatis revolutis, perianthium parvum, segmentis aequalibus, ovarium subglobosum truncatum glanduloso-puberulum, sepala oblanceolata saepe mucronulata extus ad basin glanduloso-pubescentia luteo-rubra; petala unguiculata lutea ad apicem purpureo-maculata.

Vine; stem slender, wiry, subterete, glabrous, glandular-puberulent at tip, leafy (internodes 1 5 to 3 cm. long); leaves narrowly oblong or lanceolate-oblong, 1 5 to 3 5 cm long, 0.4 to 1 cm wide, subacute and callous-thickened at apex, rounded or rarely acutish at base, petiolate (petioles 2 to 5 mm. long), slightly revolute, 9 to 15-nerved (nerves uniform, elevated on upper surface, the cross-veins prominent), coriaceous, dark green, glabrous and sublustrous above, paler beneath, strigillose with crispate hyaline hairs on the nerves beneath; bracts 3 or 4, similar to the leaves; umbel compound, 2 or 3-rayed, the rays up to 4 cm. long, glandular-puberulent, once or twice forked, bracteolate at the forks, the bracteoles linear-lanceolate, 5 to 8 mm long, up to 2 mm. wide, acuminate, revolute; flowers 1 to 1.5 cm. long, the sepals and petals equal, ovary subglobose, truncate, glandular-puberulent; sepals oblanceolate, often mucronulate, proximally glandular-pubescent without, otherwise glabrous, yellow-red, petals unguiculate, the claw and blade nearly equal in length, yellow, blotched distally with purple; stamens 5 to 7 mm. long, included, the anthers ovate-oblong, about 2 mm. long.

Type in the Field Museum of Natural History, no 535,916, collected at Playapampa, Department of Huánuco, Peru, altitude about 2,800 meters, June 16 to 24, 1923, by J F Macbride (no. 4870). Duplicate in U. S. National Herbarium.

This species belongs to the small group of *Bomarea* with relatively inconspicuous flowers in a compound umbel, of which *B. salsilla* L is the best-known representative. *Bomarea nematocaulon* is a more slender plant than *B salsilla*, the leaves are much thicker and have more numerous, more prominent, uniform nerves, and the petals are differently marked. The size and shape of the leaves and the small flowers suggest *B sclerophylla*, a plant of the simple-rayed group of *Bomarea*, which, in addition, has glabrous leaves

Bomarea angustissima Killip, sp. nov

Caulis volubilis glaber, folia linearia caudato-acuminata subsessilia revoluta 7-9-nervia coriacea supra glabra subtus in nervis leviter pilosula; bracteae lineari-lanceolatae reflexae; umbella 3-radiata, radiis arcuato-adscendentibus

glabris 1-2-furcatis, bracteolis lineari-lanceolatis acutis; ovarium turbinatum glabrum; sepala oblanceolata obtusa; petala unguiculata sepala aequantia, medio abrupte dilatata, apice suborbiculata, viridia, intus purpureo-maculata

Vine; stem subterete, tortuose, glabrous, light golden-brown; leaves linear, 8 to 10 cm. long, 3 to 5 mm wide, caudate-acuminate and tortuose at apex, subsessile, strongly revolute, 7 or 9-nerved (nerves uniform), coriaceous, glabrous and dark green above, finely pilosulous on the nerves and glaucescent beneath; bracts linear-lanceolate, up to 1 5 cm. long and 2 5 mm. wide, reflexed; umbel 3-rayed, compound, the rays 12 to 15 cm long, arcuate-ascending, purplish distally, glabrous, once or twice furcate, bracteolate at forks, the bracteoles linear-lanceolate, 0 5 to 1 cm. long, acute, ovary turbinate, glabrous, gradually tapering to base, sepals oblanceolate, 2 cm. long, 7 to 8 mm wide, slightly cucullate, obtuse, proximally deep red, distally green; petals unguiculate, as long as the sepals, abruptly dilated at middle, the upper part suborbicular, about 1 cm. wide, green, purple-blotched within; stamens about as long as the perianth, the anthers oblong, 5 mm long

Type in the herbarium of the Field Museum of Natural History, no. 535,495, collected at Tambo de Vaca, Peru, altitude about 4,000 meters, June 10 to 24, 1923, by J F. Macbride (no 4409)

This is at once distinguished from all other Peruvian species of *Bomarea* by its very long, narrow leaves.

Bomarea speciosa Killip, sp. nov

Caulis volubilis crassus glaber; folia late lanceolata cuspidata plana ca. 60-nervia membranacea glabra; bracteae lineari-lanceolatae mox deciduae; radii umbellae 10–12 crassi rufo-pilosuli viscidi 1 (raro 2)-furcati 1-bracteolati, bracteolis anguste oblongo-lanceolatis sessilibus; sepala oblanceolata subconcava ad apicem crassiora extus tenuiter puberula; petala sepalis subaequalia spathulata, extus alba et viridia puberula, intus alba, margine viridia, ubique purpureo-maculata et -punctata

Vine; stem stout, tortuose, glabrous; leaves broadly lanceolate, 15 to 20 cm long, 4 5 to 5 cm wide, cuspidate-acuminate at apex, rounded at base, petiolate (petiole stout, about 1 cm long), not revolute, about 60-nerved (nerves uniform), membranous, glabrous, bracts linear-lanceolate, about 2 cm. long, early deciduous, umbel compound, the primary rays 10 to 12, about 15 cm long, stout, rufo-pilosulous, viscid, once or (rarely) twice furcate, bearing at the forks a narrowly oblong-lanceolate, sessile, rufo-puberulent bractlet up to 3 cm long and 8 mm wide, the secondary rays up to 6 cm long; sepals oblanceolate, 4 to 5 cm long, 8 to 10 mm wide, slightly concave, apically thickened, pink, finely puberulent without, petals spatulate, subequal to the sepals, 12 to 15 mm wide, the outside white proximally, green distally, the midnerve pink, puberulent, the inside white, green at margin, blotched and dotted with purple throughout, stamens and pistil subequal, slightly shorter than the sepals, anthers oblong, about 4 mm long; style cleft about 1 cm.

Type in the herbarium of the Field Museum of Natural History, no. 534,773, collected in the montaña, Yanano, Department of Huánuco, Peru, altitude 1,800 meters, May 13 to 16, 1923, by J F Macbride (no. 3711) Duplicate in U. S. National Herbarium

This belongs to the group of *Bomarea* species having a compound inflorescence and the perianth segments subequal. The very large flowers indicate an alliance with *B. hookeriana*, a plant with leaves densely strigillose beneath, and with much shorter, more numerous umbel rays. This may be *B. macrocarpa*, which I know only from Ruiz and Pavon's description and figure, and which has usually been considered a form of *B. ovata* There are, however, many points of difference between the Macbride specimen and the diagnosis of *B. macrocarpa*.

Bomarea dolichocarpa Killip, sp. nov.

Caulis volubilis glaberrimus; folia lanceolata vel ovato-lanceolata, 25-30-nervia, nervis alternis prominentibus, membranacea utrinque glabra vel subtus in nervis tenuiter pilosa, radii primarii umbellae 3–6, 3–4-furcati bracteolati, bracteolis lineari-lanceolatis, ovarium anguste obprismaticum plus quam duplo longius quam latum, basi attenuatum glabrum vel leviter rufo-puberulum, sepala oblonga obtusa; petala spathulato-unguiculata sepalis aequalia vel parum breviora, ad basin rosea, ad apicem viridia purpureo-maculata.

Vine, with an elongate glabrous stem, petioles up to 1 cm. long; leaves lanceolate or ovate-lanceolate, 10 to 15 cm long, 1 5 to 3 5 cm wide, acute at apex, subcuneate at base, 25 to 30-nerved (alternate nerves prominent), membranous, glabrous throughout or finely pilose on the nerves beneath, bracts similar to the leaves, smaller, umbel compound, the rays up to 25 cm long, glabrous or finely pilosulous, the primary rays 3 to 6, 3 or 4 times forked, bracteolate at forks with a linear-lanceolate bractlet up to 2 cm long at the lowest fork, the upper bracteoles much smaller, ovary narrowly obprismatic, more than twice as long as broad, attenuate at base, glabrous or finely rufo-puberulent, sepals oblong, 2 to 3 cm long, 6 to 9 mm wide, obtuse, pink proximally, green distally, petals spatulate-unguiculate, as long as or slightly shorter than the sepals, 6 to 7 mm wide, pink proximally, green and densely purple-spotted distally, stamens 1 5 to 2 cm long, the anthers ovate, 2 5 to 3 mm long; fruit narrowly obprismatic, 3 5 to 4 cm long, 1 3 to 1 5 cm. wide, attenuate at base, apparently 1-celled

Type in the U S National Herbarium, no 1,460,267, collected at Puerto Yessup, Department of Junín, Peru, altitude 400 meters, July 10, 1929, by E P Killip and A C Smith (no 26306) Duplicates at New York Botanical Garden and Field Museum

Additional specimens examined —

PERU San Martín San Roque, 1,350 to 1,500 meters, *L Williams* 7022, 7326, 7771, 7679. Loreto Puerto Arturo, near Yurimaguas, *L Williams* 5290.

All these specimens have an elongate slender ovary, which becomes an elongate fruit nearly 4 cm long, noticeably tapering to the pedicel Because of its compound inflorescence, with the perianth segments subequal, the species obviously is related to *B ovata*, a fact borne out by the coloring of the flowers *Bomarea ovata* is the earliest described of the species of *Alstroemeria* now referred to *Bomarea* It shows a good deal of variation and the list of names synonymous with *B ovata* is a long one Possibly one of these names applies to the species here proposed, but I have seen type material or illustra-

tions of most of these earlier species and none of them show the characteristic ovary of *B. dolichocarpa*

BOTANY.—*A new species of* Hymenophyllum *from Peru.*[1] C. V. MORTON, U. S. National Museum. (Communicated by WILLIAM R. MAXON).

Mr. C. Bues, of Quillabamba, Peru, has collected many very interesting Peruvian ferns. A considerable number of these have been received by the U. S. National Museum through the kindness of Professor Fortunato L. Herrera, of the University of Cuzco. Included in the collection is a remarkable species of *Hymenophyllum*, here described as new.

Hymenophyllum amabile Morton, sp nov

Fig 1

Euhymenophyllym; rhizoma longe repens parce ramosum fuscum 0 5 mm diametro, pilis furcatis flavidis flaccidis pluricellularibus instructum, radicibus numerosis, stipites 2 5–6 cm longi, 0 5 mm diametro, teretes nec alati nigri nitidi dense pubescentes, pilis fuscescentibus stellatis stipitatis, demum glabrata; rhachis recta, teres, haud alata, 0 5 mm diametro, pilis densissimis eis stipitis similibus, laminae pendulae lineares, 21–35 cm longae, 3–4 cm latae, pinnatae, pinnis pinnatipartitis, pinnae ovatae vel oblongae, maximae 2 5 cm. longae et 1 5 cm latae, apicem versus gradatim reductae, sessiles, paullo decurrentes, haud surcurrentes, margine venisque densissime griseo-ferrugineo-pubescentes, pilis stipitatis ramis numerosis stellatis, rhachibus venisque vix flexuosis nigris, lamellae desunt, segmenta inferiora pinnatipartita, superiora semel furcata vel integra; segmenta ultima oblonga, maxima 4 mm longa, omnia ca 1 mm lata, obtusa nec emarginata, nervis apicem non attingentibus, simplicia vel semel furcata, sori in lobulis extremis haud abbreviatis terminales, indusium non immersum, ad basin bilobum, lobis transverse ovalibus, ca 0 6 mm altum, 1 mm latum, tenuissime membranaceum, fragile, margine integrum, extus densissime pubescens et ciliatum, pilis stellatis, sporangia numerosa in apicibus capitatis receptaculorum

Type in the U S National Herbarium, no 1,515,445, collected at Michihuañuncca, Huadquiña, Prov de la Convención, Dept. Cuzco, Peru, alt. 3,000 meters, December, 1920, by C Bües (no 715)

Hymenophyllum amabile belongs to the *H sericeum* group of species It is distinguished at once from that species and its relatives *H tomentosum*, *H. pyramidatum*, *H. lobato-alatum*, *H fusugasugense*, and *H plumosum* by the absence of wings on the secondary rhachises and veins The remaining species of the group are *H. pulchellum*, *H karstenianum*, *H chrysothrix*, *H. spectabile*, *H refrondescens*, *H speciosum*, *H buchtienii*, *H elegantulum*, *H. sprucei*, *H trichophyllum*, and *H interruptum* The last four named are

[1] Published by permission of the Secretary of the Smithsonian Institution Received December 24, 1931.

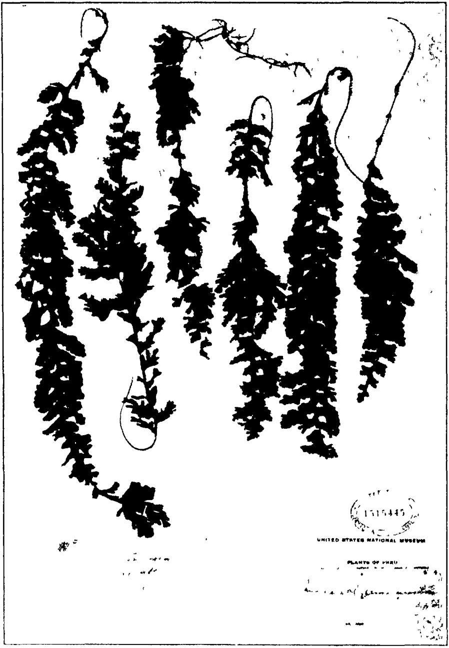

Fig 1 *Hymenophyllum amabile* Morton, type specimen Slightly less than one half natural size

quite unrelated to the present species. The close, fine pubescence of *H. karstenianum*, *H. spectabile*, and *H. speciosum*, in which the individual hairs are not apparent except under magnification, is very different from the coarse pubescence of *H. amabile*, in which the individual hairs are prominent. All three of these species differ from ours also in their elongate, acuminate (rather than ovate or oblong, obtuse) pinnae. *H. buchtienii* Rosenst. and *H. pulchellum* C. & S. have pubsecence somewhat similar to the present species, but the hairs are less coarse and are sessile or only short-stipitate, in contrast to those of *H. amabile* which are long-stipitate. *H. buchtienii* (from Bolivia) is moreover a much smaller and more delicate plant with non-decurrent pinnae. *H. pulchellum* has a very different range (Mexico) and differs in several particulars from the present species, especially in its smaller size and less divided, petiolate (rather than sessile) pinnae. *H. refrondescens* Sod., of Ecuador, differs conspicuously in its alate rhachises and adnate pinnae; it is known to me from description only. *H. amabile* has terete non-alate rhachises and nearly free pinnae, i. e. not at all surcurrent and only slightly decurrent. *Hymenophyllum chrysothrix* Sturm, a little known species of Venezuela and Brazil, is perhaps most closely related, differing in its finer, less dense pubescence, broadly lanceolate (rather than linear) blade, petiolate (not at all decurrent) pinnae, and subimmersed indusia. The indusium of *H. amabile* is not at all immersed in the leaf tissue.

ZOOLOGY.—*Spawning reactions of three species of oysters.*[1] PAUL S. GALTSOFF, U. S. Bureau of Fisheries.

Since 1927 the author has been engaged in a study of the factors that control the shedding of eggs and sperm of the eastern oyster, *Ostrea virginica*. In 1929 the opportunity presented itself to experiment with the Japanese oyster, *O. gigas*, grown in Puget Sound, and during the summer of 1930 several experiments were carried out with the Australian oyster, *O. cucullata*, and *O. virginica* grown in the waters near Honolulu, T. H. A complete report of these investigations comprising nearly four hundred experiments will be published in the Bulletin of the Bureau of Fisheries.

The technique employed in all the experiments consisted in placing the oyster in a tank of about 20 or 30 liter capacity, in which the water was aerated, stirred and kept at constant temperature. In the majority of the experiments the thermo-regulators were set at 22.5°C. and they maintained this temperature within 0.5°C. The oyster was immobilized with plaster of Paris and one of its valves was attached to a light kymograph lever made of a strip of celluloid. It has been shown

[1] Published by permission of the U. S. Commissioner of Fisheries. Received January 5, 1932.

in a previous paper[2] that spawning of the female oyster consists of a series of the following reactions: contractions of the mantle, rhythmical contractions of the adductor muscle, and discharge of eggs. Rhythmical contractions of the muscle enable one to obtain a permanent record which can be easily analyzed. The results of a large number of experiments with *O. virginica* carried in 1927–1929 show that no spawning occurs below 20.0°C., whereas the same specimen reacts to the same suspension of sperm as soon as the temperature has been brought above 20.0°. In a few instances it has been noticed that oysters spawned at 27.5° without being stimulated by sperm. Inasmuch as in those cases unfiltered water was used the possibility of its contamination with sperm was not excluded. In the experiments with *O. gigas* it has been found that a ripe female oyster can be induced to spawn by a temperature of 30.0°C. The question naturally arises whether the same results could not be obtained with the other species. During the summer of 1931 experiments were carried out at Woods Hole with ripe oysters which were kept in aquaria at a temperature of about 20.0°C. To avoid possible contamination the water used in the experiments was filtered through a layer of asbestos about three quarters of an inch thick The results of the experiments, summarized in Table 1, indicate without any doubt that ripe females can be induced to spawn by placing them in water having a temperature from 24.5° to 30.0°C. At 31.0°C. the females usually close their valves and remain closed until the temperature drops to 30° or 29°.

The latent periods of spawning reactions, i.e. the time elapsed from the moment the oyster was exposed to a given temperature until the beginning of spawning, varies from 22 to 257 minutes and apparently is not correlated with the temperature, the quickness of the response probably depending on the conditions of the organism itself. In a series of other experiments which can not be described in a brief article, the females which failed to respond to high temperature (26°–30°C.) readily responded to the addition of sperm. In all the experiments recorded in Table 1 the eggs discharged by the oysters were unfertilized and did not develop. The fact that the females can be stimulated by a temperature of 24.5° or higher suggested the possibility that a similar effect might be obtained by a longer exposure to temperatures between 20.0° and 24.5°C. The results of a long number of experiments, of which only three will be here described,

[2] Proc Nat Acad Sci 16: 555–559 1930.

show that this is very doubtful. On July 10 three ripe females were taken from the tank, in which the temperature during the previous week fluctuated between 18 5° and 19.5°C., and placed in an aquarium filled with filtered sea water. The temperature was kept at 22.6°C. but occasionally rose to 23.4°C. The shell movement of each oyster was recorded on the kymograph. The first oyster was kept for 5 hours 22 minutes, the second for 29 hours 53 minutes, and the third one for 73 hours 13 minutes. The water in the tanks in which the second and third oysters were kept was changed twice a day. None of the oysters spawned during that time but each of them spawned after sperm was added to the water the latent periods being 16, 24 and 15 minutes respectively.

TABLE 1.—SPAWNING REACTIONS OF THE FEMALES OF O VIRGINICA INDUCED BY TEMPERATURE

Date in 1931	Experiment No	Temperature °C		Latent period in minutes	Duration of spawning in minutes
		Before experiment	During experiment		
July 10	325	19 5	24 5	65	43
9	321	19 9	25 0	22	118
7	317	19 9	25 3	250	46
9	322	19 9	26 0	257	38
8	318	19 9	28 0	32	25
8	319	19 9	28 5	55	44
17	340	20 4	30 0	20	?
8	320	19 9	30 0	42	52

It is interesting to note that in both cases of stimulation either by the temperature or by the sperm the reaction is alike and is characterized by a series of rhythmical contractions of the adductor muscle and of the mantle. From that an inference can be made that both factors release some mechanism in the organism of the female which in turn stimulates the adductor muscle and causes the discharge of eggs from the ovary. In this respect the reaction is not specific. It is, however, specific in the sense that sperm of other mollusks (*Mya* spp., *Mytilus* spp.) fail to induce spawning of the oyster. No positive results were obtained also when the sperm of *O. cucullata* was added to the female of *O. virginica* and vice versa. The last experiments are not conclusive, however, because of the failure of the specimens used in the experiments to spawn immediately upon the addition of the sperm of the same species. A few days later the shedding of eggs was successfully

stimulated by adding sperm of the same species. Attempts to fertilize eggs of *O. cucullata* by sperm of *O. virginica* and *vice versa* were unsuccessful. There was no formation of the fertilization membrane and no cleavage, whereas in the controls the eggs developed fairly well.

The spawning reaction of the male consists in a discharge of sperm which is carried away by the stream of water produced by the gill epithelium. The reaction is much simpler than it is in the female; it does not involve the adductor muscle and therefore can not be recorded on a kymograph. The males respond to the increase in temperature more readily than the females and often spawn in the tanks when the temperature reaches 24°C. Similar to the spawning of the females the shedding of sperm can be easily provoked by the addition of a few drops of egg suspension or egg water. Unlike the female in which the latent period lasts for several minutes the latent period of the spawning reaction of the male is of brief duration. It lasts only a few seconds. The reaction can be repeated many times until the male is spent. In case of *O. gigas* the males respond to egg suspension even when the water has been cooled to 12.5°C.

In 1930 several experiments with the two species of oysters, *O. virginica* and *O. cucullata*, were performed at Honolulu. The males failed to respond to the addition of sperm of another species but immediately reacted by discharging sperm to the addition of eggs of the same species. These results indicate very clearly the specificity of the response of the male to the presence of eggs. It would be very interesting to extend these experiments to other species of oysters the taxonomic characters of which, as for example those of *O. virginica* and *O. angulata*, are rather indistinct. There is no doubt that physiological differences that might be found would help in determining the validity of the present definitions of various species of the genus *Ostrea*.

Besides being stimulated by the temperature and egg suspension the males of *O. virginica* can be stimulated also by sperm. In that case the latent period of the reaction is approximately of the same duration as it is in the case of the stimulation of the female. A probable explanation is that the active principle of sperm suspension, being insoluble in the sea water, acts upon the organism through the digestive tract.

From a biological point of view stimulation of spawning either by the temperature or by the sperm and egg suspension is of great interest. It provides a mechanism which insures successful propagation of the

species. Should the temperature of the water fail to reach the effective point which would induce shedding of eggs by the females, still the spawning of the latter could be provoked by the sperm discharged by the males which are more susceptible to the increase in temperature. In most of the cases observed by the author when several oysters were kept together, the males spawned first and induced the shedding of eggs by the females. The process, once started, spreads by mutual stimulation of the two sexes throughout the whole oyster bed and results in simultaneous spawning of the oyster population.

MALACOLOGY.—*A new land shell of the genus* Rhiostoma *from Siam.*[1]

PAUL BARTSCH, U. S. National Museum.

Dr. Hugh M. Smith, Fisheries Adviser to His Majesty's Government, Bangkok, Siam, has sent to me for determination a magnificent specimen of *Rhiostoma*, which he collected at Kao Sabap, southeastern Siam, June 28, 1931, at an elevation of 450 meters.

Rhiostomas are ground-dwelling mollusks that frequent leaf mulch, burying themselves beneath such debris, and coming to the surface on moist days. Among a dozen or more known species of *Rhiostoma*, the present one has only one rival for size, namely, *Rhiostoma hainesi* Pfeiffer, from which it is at once distinguished by its lesser number of whorls, *Rhiostoma smithi* having but 5, while *Rhiostoma hainesi* has 7.

Rhiostoma smithi, n sp

Fig. 1

The shell is depressed helicoid, excepting the last two-fifths of the last turn which are solute, and which are deflected outward and downward The under surface is openly umbilicated, all the whorls showing within the umbilicus. The early turns are straw-colored, the later whorls tending to pale olivaceous brown. In the type there are no color markings beyond this except an occasional darker varicial streak. (On the two paratypes, however, we have a subperipheral zone of chestnut brown and fine narrow axial vermiculations of brown. These, however, are not very conspicuous.) The early whorls are sufficiently eroded on the upper surface to make it impossible to differentiate the termination of the nuclear portion in the three specimens before us The sculpture begins to show on the last half of the second whorl; from there on the shell is covered by a moderately thick periostracum. The sculpture of the shell consists of numerous, slender, threadlike wrinkles which assume almost the strength of slender lamellae on the summit of the whorls near the suture where they have been protected. This in reality represents projecting portions of the periostracum. These incremental threads are closely approximated and are of somewhat varying strength. They give to

[1] Published by permission of the Secretary of the Smithsonian Institution Received December 18, 1931.

the surface of the shell a decidedly wrinkled appearance. What is said of the sculpture on the dorsal surface also obtains on the under side of the shell, the lines of growth extending into the umbilicus. The solute portion of the last whorl shows a feeble carina, corresponding to the posterior angle of the aperture, which is rendered conspicuous by the fact that the periostracum here is worn and leaves a white streak This carina terminates anteriorly in the ear of the peristome The aperture is circular; the peristome is double, forming an ear or anteriorly open tube at the posterior angle of the aperture. *This ear is rather short The outer peristome is conspicuously expanded* from the ear to the middle of the basal lip, becoming decidedly narrow on the parietal wall The inner peristome projects slightly above the outer and is very slightly reflected Both of them contribute to the production of the ear. The operculum forms a multispiral elevated cone, which is slightly concave in the middle on the outside. There are more than 14 whorls to the operculum. The outer portion of the operculum consists of an oblique calcareous lamina, which is spirally disposed and which bears on its outer surface a brownish periostracum which extends for a distance equaling the width of the lamella, beyond this being cut up into ragged fringes. The inside of the operculum is deeply cupped.

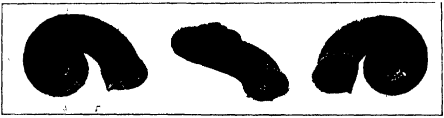

Fig 1 *Rhiostoma smithi*

The type, U S N M No 382943, has 5 whorls, and measures: Altitude, 20.3 mm.; greater diameter, 34 5 mm.; lesser diameter, 21.0 mm.

Two paratypes, U. S. N. M. No. 382944, have each 5 whorls, and measure: Altitude, 21 mm., 19.8 mm.; greater diameter, 34 mm , 32 3 mm.; lesser diameter, 22.3 mm., 20 2 mm., respectively.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

243D MEETING

The 243d meeting of the ACADEMY was a joint meeting with the Washington Society of Engineers and the District of Columbia Section of the American Society of Civil Engineers, and was held in the Auditorium of the Interior Department Building, on Thursday, November 19, 1931. About 200 persons were present. President COBB called the meeting to order at 8:20 P M., and turned the chair over to Dr. R S PATTON, Director of the Coast and Geodetic Survey who introduced as speaker of the evening, Professor JYOJI SUYEHIRO, Director of the Earthquake Research Institute of The Tokyo Imperial University, who delivered an illustrated address, an abstract of which follows:

Program: J. SUYEHIRO: *Engineering aspects of earthquake research in Japan.* Two subjects were covered in this lecture—the Idu earthquake of November 26, 1929, and the effect of vibrations on buildings. The earthquake menace is accentuated in Japan because of the dense population but in fact very strong shocks occur only about once in 30 years The numerous fore and after-shocks are often strong enough, however, to cause damage. As a result of the very great importance of these shocks to the people of Japan the interest of the Earthquake Research Institute, which was founded after the destructive shock of 1923, has been primarily directed towards local shocks rather than teleseismic shocks.

While the 1929 shock was in no way comparable with the great disaster of 1923, 261 persons lost their lives and 2,000 houses were destroyed. The shock is believed to have originated in the 30 km long Tanna fault running north and south near the middle of the peninsula A northward displacement of three feet is found on the east side of the fault A large tunnel which crosses the fault was under construction at the time No very serious damage occurred though the minor fault lines crossed the tunnel in about six different places. The ground through which the tunnel runs is mostly volcanic ash with some rock intrusion. Special instruments were installed to measure the minute slipping which continued after the main shock

Fore shocks began 19 days in advance Seven hundred and eighty-nine shocks were recorded in one day and 4,000 over a period of 56 days Tilt measurements in this case showed nothing which could have been considered as predicting an earthquake This may be related to the fact that the motion was chiefly horizontal It happened that a line of levels was being run on the day before the earthquake in one direction and was repeated on the day afterwards but showed no difference The change across the main fault was 20 cm Triangulation results are not yet available Seismographs in the tunnel and outside, constructed of stainless steel on account of the moisture, gave similar records except that small short-period vibrations on the outside instruments did not show up on the underground records

For the purpose of studying the effects of earthquakes on buildings the latter are divided into three classes—strong, fairly strong, and weak In the case of strong buildings the record made at the top of the building agreed very closely with that of the ground In fairly strong buildings the similarity was not so marked while in weak buildings the record at the top showed almost entirely the natural period of the building and not the earthquake effect.

The inference to be drawn is that in designing buildings both forced and free vibrations must be considered The view was expressed that the fate of a building is decided in the first 10 seconds of the shock It is also felt in Japan that accelerations corresponding to periods of less than 1/3 second need not be considered in the study of strong earthquake motions as they are considered to be within the elastic limits of most structures The opinion was further expressed that, while there is no real basis for adopting the maximum acceleration at any given percentage of g, such a practice with a properly adopted factor of safety is about the best that can be done until our knowledge becomes more complete.

CHARLES THOM, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

ANDREW THOMSON, previously aerologist for the Meteorological Service of New Zealand and for some years director of the Apia Observatory, has been appointed meteorologist in the Canadian Meteorological Service.

DR. FREDERICK V. COVILLE, Curator of the Division of Plants of the National Museum, was recently awarded the George Robert White Gold Medal of Honor by the Massachusetts Horticultural Society for distinction in botanical fields

At the thirty-ninth annual meeting of the Geological Society of Washington, held December 9, 1931, the following officers were elected· *President*, F. E. MATTHES; *Vice-Presidents*, F L HESS and H. G. FERGUSON, *Secretaries*, J F SCHAIRER and W H. BRADLEY, *Treasurer*, C WYTHE COOKE; *Members-at-large of the Council*, E P HENDERSON, T. B. NOLAN, FRANK REEVES, C E RESSER, and F. G. WELLS.

The Pick and Hammer Club met at the Geological Survey January 15 H D MISER discussed the conduct of the fifth annual field conference of the Kansas Geological Society, R. H SARGENT described the work of topographers of the Geological Survey in Alaska and showed many colored slides, JOSIAH BIRDGE showed three reels of motion pictures of geologists at work in the southern Appalachians and other regions

At a special meeting of the Pick and Hammer Club held at the Geological Survey, January 21, DR F A VENING MEINESZ, professor of geodesy at the University of Utrecht, told of his work in a submarine on determinations of gravity at sea in the East and West Indies.

At the annual meeting of the American Anthropological Association held at Andover, Mass , December 28 and 29, 1931, Dr JOHN R SWANTON of the Bureau of American Ethnology was elected president for the ensuing year; DR JOHN M COOPER, Professor of Anthropology in the Catholic University of America, was reelected secretary, and Dr. FRANK H H ROBERTS of the Bureau of American Ethnology was made an associate editor of the *American Anthropologist*, the organ of the association

The Cosmos Club on January 18 elected officers as follows. JOHN H. HANNA, *President*, ARTHUR L. DAY, *Vice-President*, D L. HAZARD, *Secretary;* GEORGE E. FLEMING, *Treasurer;* HENRY GRATTAN DOYLE, HENRY C FULLER, and NEIL M JUDD, *Managers to serve until 1935*, JOHN H. MACCRACKEN, DELOS H SMITH, and JOHN VAN RENSSELAER, *Members of the Committee on Admissions;* VICTOR S CLARK, E. DANA DURAND, and J. WILMER LATIMER, *Members of the Endowment Fund Committee.*

H. W. KRIEGER, Curator of Ethnology, National Museum, left January 16 for the West Indies, where he will investigate shell heaps and other aboriginal remains on the islands of San Salvador and Cuba.

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MATHEMATICS.—*A comparison of certain symmetrical growth curves*.[1] CHARLES P. WINSOR. (Communicated by RAYMOND PEARL.)

In recent years much has been written on the mathematical representation of growth, both of organisms and of populations. Various equations have been used for the purpose, either selected empirically or derived from more or less rational biological considerations. In particular the equation

$$y = \frac{k}{1 + e^{a - bx}} \tag{1}$$

derived by Verhulst, and by him called the logistic, has been used extensively. (For full references, see Pearl (5).) As is well known, this curve has asymptotes $y = 0$ and $y = k$, no point of zero slope between the asymptotes, and a point of inflection when $y = k/2$.

It is of course clear that there are many other curves which possess similar properties. The question has been raised (among others, by Bowley (2) and Davies (3)) as to why the use of the logistic should be preferable to that of the integrated normal curve.

In general the choice of a mathematical function to represent observed data is influenced by two different considerations. We may have, or think we have, *a priori* knowledge of the mechanics of the phenomenon, from which we may deduce that the data should follow a certain law. More often, in biological work, the underlying causes and their mode of action are so obscure that we are in no position to make sound deductions about laws, we have to infer our law from the observations. We shall, under such conditions, probably be guided

[1] From the Department of Biology of the School of Hygiene and Public Health of the Johns Hopkins University. Received January 2, 1932.

by some such considerations as these: (1) we want a function which is mathematically simple, both in its functional form and in the number of arbitrary constants involved, (2) the function must reproduce the observations with reasonable fidelity, (3) the function must not lead to absurdities on extrapolation. Obviously, these considerations are not sufficient, in the mathematical sense; different workers will interpret them differently, and it may be quite impossible to reconcile differences of opinion which may arise.

In the particular case which interests us here, we seem to be faced with just this kind of problem. There is little understanding or agreement as to the underlying mechanism of growth; there is a considerable body of data on growing individuals and growing populations. In particular, it has been found that many sets of growth data can be fitted, more or less closely, with logistic curves. But clearly this does not exclude the possibility that they might be as well, or better, fitted with some other curve.

It is the primary purpose of the present paper to make a mathematical comparison of certain symmetrical curves, not with observational material, but with each other, with a view to determining how different in form they actually are. Clearly whether it is actually possible to discriminate between functions on the basis of goodness of fit to observations will depend in part on the differences between the curves themselves, and in part on the regularity or irregularity of the observations. It is useful to compare the curves as curves, since we can then form an opinion as to whether observational material is likely to be regular enough to furnish an adequate test of one hypothesis as against another.

The particular curves which will be considered here are the logistic, the integrated normal curve, the arc-tangent curve, and the integrated Pearson Type VII curve.[2] The equations to these curves are:

Logistic.
$$y_L = \frac{k}{1 + e^{a - bx}} \tag{1}$$

Integrated Normal
$$y_N = \frac{k}{\sqrt{2\pi}\,\sigma} \int_{-\infty}^{x} e^{-\frac{1}{2}\left(\frac{x - x_0}{\sigma}\right)^2} dx \tag{2}$$

Arc-tangent
$$y_T = \frac{k}{\pi} \tan^{-1}\left(\frac{x - x_0}{a}\right) + \frac{k}{2} \tag{3}$$

[2] There are of course many other symmetrical growth curves which might with equal reason be used, e.g., $y = K \tan^{-1} e^{ax + b}$

Integrated Type VII: $y_p = y_0 \int_{-\infty}^{x} \left(1 + \frac{(x - x_o)^2}{a^2}\right)^{-m} dx$ (4)

For purposes of comparison, we shall make the upper asymptote unity for all curves; and we shall choose the time origin at the point of inflection. This will leave us one constant in each of the first three curves, and two in the Pearson curve, to be determined. Further, it is convenient to set $\sigma = 1$ in the integrated normal curve, since this enables us to read its ordinates direct from Sheppard's Table. This throws our equations into the form:

Logistic. $$y_L = \frac{1}{1 + e^{-bx}} \tag{1'}$$

Integrated Normal: $$y_N = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} e^{-\frac{1}{2}x^2} dx \tag{2'}$$

Arc-tangent $$y_T = \frac{1}{\pi} \tan^{-1}\left(\frac{x}{a}\right) + \frac{1}{2} \tag{3'}$$

Integrated Type VII $$y_P = \frac{\Gamma(m)}{a\sqrt{\pi}\,\Gamma(m - \frac{1}{2})} \int_{-\infty}^{x} \left(1 + \frac{x^2}{a^2}\right)^{-m} dx \tag{4'}$$

The natural method to follow in fixing the values of the constants of these equations would be the method of least squares, this, however, involves us in difficult integrations, and it is questionable how far the results obtained would be of value in practice.[5] The method of moments is perhaps the next that occurs to one, naturally not the moments of the curves themselves, but of their first derivatives. This method may be followed for comparing equations (1), (2), and (4), but in the case of the arc-tangent curve the second moment of the derivative is infinite.

We may also determine the constants by fixing the points of intersection of the curves. This will be simple in the case of all but equation (4). We shall arbitrarily set the points of intersection at $y = \frac{1}{4}$, $y = \frac{1}{2}$, $y = \frac{3}{4}$. By symmetry, an intersection at $y = (\frac{1}{2} - a)$ determines an intersection at $y = (\frac{1}{2} + a)$

[5] In practice, we are dealing only with a finite segment of the curve, and in general only with that portion where growth is active, but a least squares solution gives equal weight to differences wherever they occur

We shall have then two comparisons (A) equations (1), (2), and (4) compared by the method of moments, and (B) equations (1), (2), and (3) compared by fixing points of intersection at $y = \frac{1}{4}$, $y = \frac{1}{2}$, $y = \frac{3}{4}$

We obtain the following equations

Comparison A.

Logistic $$y_L = \frac{1}{1 + e^{-\pi x/\sqrt{3}}}$$

Integrated Normal $$y_N = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} e^{-\frac{1}{2}x^2}\, dx$$

Integrated Type VII $$y_P = \frac{2^7}{35\,\pi\sqrt{7}} \int_{-\infty}^{x} \left(1 + \frac{x^2}{7}\right)^{-5} dx$$

Comparison B

Logistic $$y_L = \frac{1}{1 + e^{-1.62880\,x}}$$

Integrated Normal $$y_N = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} e^{-\frac{1}{2}x^2}\, dx$$

Arc-tangent $$y_t = \frac{1}{\pi} \tan^{-1}\left(\frac{x}{.67449}\right) + \frac{1}{2}$$

Tables 1 and 2 show the ordinates of each of these curves for comparisons A and B respectively, Figures 1 and 2 show the course of the the curves graphically It will be noted that the Type VII curve gives a much closer fit to the logistic than the normal curve, this, of course, is to be expected, since we have equated one more moment. It will also be observed that in comparison B we have a distinctly closer agreement between the normal curve and the logistic than in Comparison A, over that part of the growth cycle that is of greatest interest to us We may infer that the method of moments is not the best method for use in this particular case, and that perhaps a still better fit would be obtained by the method of least squares [4]

The comparison may be made in another way, which may be of interest Values of $\frac{k - y}{y}$ plotted on semi-log paper give a straight

[4] Subject to the consideration in the previous foot-note

line if y follows a logistic If we plot values of $\frac{k-y}{y}$ for other equations, we shall have curves which approach a straight line more or less closely as the curves themselves approach the logistic more or

TABLE 1 — COMPARISON OF INTEGRATED NORMAL, LOGISTIC, AND INTEGRATED TYPE VII CURVES CONSTANTS DETERMINED BY METHOD OF MOMENTS

x	Integrated Normal	Logistic	Integrated Type VII
0	5000	5000	5000
2	5793	5897	5871
4	6554	6738	6695
6	7257	7481	7433
8	7881	8102	8060
1 0	8413	8598	8569
1 2	8849	8981	8966
1 4	9192	9269	9266
1 6	9452	9479	9485
1 8	9641	9632	9642
2 0	9772	9741	9752
2 2	9861	9818	9829
2 4	9918	9873	9882
2 6	9953	9911	9919
2 8	9974	9938	9944
3 0	9987	9957	9961

TABLE 2 — COMPARISON OF INTEGRATED NORMAL, LOGISTIC, AND ARC-TANGENT CURVES POINTS OF INTERSECTION AT $y = \frac{1}{4}$, $y = \frac{1}{2}$, $y = \frac{3}{4}$

x	Integrated Normal	Logistic	Arc tangent
0	5000	5000	5000
2	5793	5806	5958
4	6554	6571	6704
6	7257	7262	7314
8	7881	7859	7771
1 0	8413	8356	8111
1 2	8849	8756	8370
1 4	9192	9069	8571
1 6	9452	9309	8730
1 8	9641	9491	8859
2 0	9772	9627	8965
2 2	9861	9728	9053
2 4	9918	9862	9128
2 6	9953	9856	9192
2 8	9974	9896	9248
3 0	9987	9924	9296

In these tables ordinates have been tabulated only for positive values of x, for negative values of x, the ordinate $y_{-x} = 1 - y_x$

less closely Figure 3 shows the values $\left(\frac{1-y}{y}\right)$ for the curves in comparison B

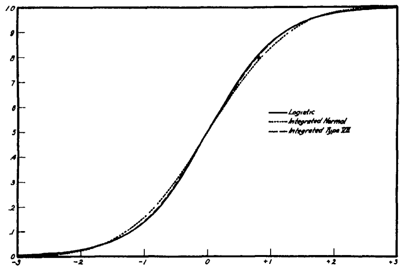

Fig 1 Logistic, Integrated Normal, and Integrated Type VII curves Equating moments

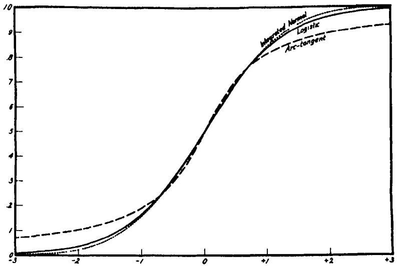

Fig 2 Logistic, Integrated Normal, and Arc-tangent Curves. Points of Intersection Fixed

From the discussion above, it appears that the logistic and the integrated normal curve are so nearly similar as to suggest a question as to whether one could discriminate between them on the basis of experimental data. It will be noted that the maximum difference in corresponding ordinates is of the order of 1.5 per cent of the asymptote, and an examination of published observational data will show but little material approaching this order of accuracy. The data of

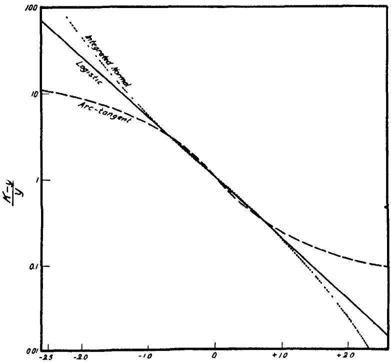

Fig. 3. Values of $\frac{1-y}{y}$ for Logistic, Integrated Normal, and Arc-tangent Curves, on arithlog paper

Carlson (1) on growth of yeast, which have been worked over by Pearl (4) and Schultz (6), are, however, sufficiently regular and sufficiently extensive to suggest an attempt at a graduation comparison.

Fitting by the method of least squares, we obtain equations as follows:

Logistic $$y_L = \frac{662.88}{1 + e^{4.27969 - .54823x}} \qquad (5)$$

$$\text{Integrated Normal.}\ y_N = \frac{658.38}{3.0634\sqrt{2\pi}} \int_{-\infty}^{x} e^{-\frac{1}{2}\left(\frac{x-7.7700}{3.0634}\right)^2} dx \qquad (6)$$

Table 3 shows the results of the graduation by these two equations. It will be observed that not merely does the logistic give a better fit, as indicated by the quadratic mean error, but that there is distinctly more tendency to systematic deviations in the case of the normal curve.

TABLE 3.—COMPARISON OF LOGISTIC AND INTEGRATED NORMAL CURVES FITTED TO GROWTH OF YEAST

Time in hours x	Observed[5] y_{obs}	Calculated		Deviations from observations	
		Logistic y_L	Normal y_N	Logistic $y_{obs} - y_L$	Normal $y_{obs} - y_N$
0	9.6	9.05	3.69	+.55	+5.91
1	18.3	15.51	8.95	+2.79	+9.35
2	29.0	26.38	19.62	+2.62	+9.38
3	47.2	44.36	39.31	+2.84	+7.89
4	71.1	73.17	71.90	−2.07	−0.80
5	119.1	117.16	120.48	+1.94	−1.38
6	174.6	179.54	185.40	−4.94	−10.80
7	257.3	259.35	263.94	−2.05	−6.64
8	350.7	349.02	348.88	+1.68	+1.82
9	441.0	436.17	432.03	+4.83	+8.97
10	513.3	509.74	504.78	+3.56	+8.52
11	559.7	564.82	562.26	−5.12	−2.56
12	594.8	602.41	603.34	−7.61	−8.54
13	629.4	626.54	629.48	+2.86	−0.08
14	640.8	641.38	644.29	−0.58	−3.49
15	651.1	650.29	652.39	+0.81	−1.29
16	655.9	655.54	656.01	+0.36	−0.11
17	659.6	658.60	657.52	+1.00	+2.08
18	661.8	660.40	658.12	+1.40	+3.68
Sum of squares of deviations =				194.88	715.20
Quadratic mean error =				3.49	6.69

[5] Data from Carlson's (1) Table VIII

It seems clear that in this instance, at least, the logistic is essentially a better growth curve than the integrated normal.

It does not appear worth while to attempt a comparison with the arc-tangent curve or with the integrated Type VII curve. The arc-tangent curve will not even approximately fit the data, the Type VII curve will perhaps give a good fit, but only at the cost of an unwarranted amount of effort.

SUMMARY AND CONCLUSION

From a comparison of the logistic equation with those for the arc-tangent curve and the integrated normal curve, it appears that the logistic and normal curves are of closely similar shape, and that both differ widely from the arc-tangent curve. It also appears that the logistic curve describes the growth of a population of yeast cells with distinctly greater accuracy than does the integrated normal curve.

I wish to thank Dr Raymond Pearl, at whose suggestion this paper was written, for his advice and criticism.

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APPENDIX

1 Moments of the logistic derivative

The logistic equation

$$y = \frac{1}{1 + e^{-bx}}$$

has for its derivative

$$y' = \frac{be^{-bx}}{(1 + e^{-bx})^2}$$

We require the moments of this derivative curve

$$\mu_n = \int_{-\infty}^{+\infty} x^n \, y' \, dx$$

Plainly all odd moments are zero, and also

$$\mu_{2n} = 2\,b \int_0^{\infty} \frac{x^{2n} \, e^{-bx} \, dx}{(1 + e^{-bx})^2}$$

Setting $bx = u$, and expanding the denominator we have

$$\mu_{2n} = \frac{2}{b^{2n}} \sum_{k=1}^{\infty} \int_0^{\infty} (-1)^{k+1} u^{2n} \, k e^{-ku} \, du$$

And changing variables again, setting $ku = v$,

$$\mu_{2n} = \frac{2}{b^{2n}} \sum_{k=1}^{\infty} \frac{(-1)^{k+1}}{k^{2n}} \int_0^{\infty} v^{2n} e^{-v}\, dv$$

$$= \frac{2\,(2n)!}{b^{2n}} \sum_{k=1}^{\infty} (-1)^{k+1} \frac{1}{k^{2n}}$$

But this is a well-known series involving the Bernoullian numbers, so that we have finally

$$\mu_{2n} = \frac{2\left(2^{2n-1} - 1\right) \pi^{2n} B_n}{b^{2n}}$$

$$B_1 = \tfrac{1}{6},\ B_2 = \tfrac{1}{30}, \text{ etc.}$$

And we have as the moments of the logistic derivative

$$\mu_2 = \frac{\pi^2}{3\, b^2}$$

$$\mu_4 = \frac{7\, \pi^4}{15\, b^4}$$

$$\beta_2 = \frac{\mu_4}{\mu_2^2} = 4.2$$

2. For comparison with the normal curve, we set

$$\mu_2 = 1$$

$$b = \frac{\pi}{\sqrt{3}} = 1.81380$$

3. We have for the values of the constants in the Pearson Type VII curve

$$m = \frac{5\,\beta_2 - 9}{2\,(\beta_2 - 3)}$$

$$a^2 = \frac{2\,\mu_2\,\beta_2}{\beta_2 - 3}$$

$$y_0 = \frac{N}{a} \frac{\Gamma(m)}{\sqrt{\pi}\,\Gamma\left(m - \frac{1}{2}\right)}$$

And setting $N = 1$, $\mu_2 = 1$, $\beta_2 = 4.2$, we have

$$m = 5,\ a^2 = 7,\ y_0 = 0.439990$$

4. To determine constants so that the logistic, integrated normal, and arc-tangent curves shall intersect at $y = \frac{3}{4}$

When $y = \frac{3}{4}$, $x = 0.67449$

for the integrated normal curve

Logistic

$$y_L = \frac{1}{1 + e^{-bx}}, \quad -bx = \log_e\left(\frac{1 - y_L}{y_L}\right)$$

$$y_L = \tfrac{3}{4}, \quad x = 0.67449$$

$$b = 1.62880$$

Arc-tangent

$$y_T = \frac{1}{\pi}\tan^{-1}\frac{x}{a} + \tfrac{1}{2}$$

$$\frac{x}{a} = \tan\left(\pi\, y_T - \frac{\pi}{2}\right)$$

$$y_T = \tfrac{3}{4}, \quad x = 0.67449$$

$$a = 0.67449$$

5. Comparison with Carlson's observations

Carlson's data are taken from his Table VIII (also given by Pearl (4) and Schultz (6)). Schultz has fitted these data by the least squares, but states that a better fit than given by his equation (53) might be obtained by a repetition of the least square procedure. Accordingly the constants in his equation (53) were used as first approximations. The results hardly justified the trouble, as the quadratic mean error was only reduced from 3.50 to 3.49.

For the least square fit to the normal curve, approximate values of the constants were selected as follows:

$$k_0 = 662$$

$$x_{o_0} = 7.8$$

$$\sigma_0 = 3.1$$

The corrections found were

$$\Delta k = -3.62$$

$$\Delta x_0 = -.030$$

$$\Delta \sigma = -.0366$$

giving final values

$$k = 658.38$$

$$x_0 = 7.770$$

$$\sigma = 3.0634$$

A comparison of the retained and neglected terms for 0, 9, and 18 hours indicated that the neglected (second order) terms were actually small in comparison with the retained terms

GEOLOGY —*Faunal zones in the Miocene Choctawhatchee formation of Florida* [1] WENDELL C. MANSFIELD, U. S Geological Survey, and GERALD M. PONTON, Florida Geological Survey.

In March, 1930, the writers discovered fossiliferous outcrops of Miocene beds in the valley of Alaqua Creek, Walton County, Florida, farther south than fossils had previously been reported from this region [2] Fossils from these beds, when studied by the senior author, showed that they belong to the Choctawhatchee formation. They not only give more substantial evidence of the close faunal relationship of the Shoal River formation to the succeeding Choctawhatchee formation but also reveal the sequence of the zones of the Choctawhatchee formation and the position in the formation of the typical deposits at Red Bay

The map (Figure 1) shows the type localities of the Shoal River and Choctawhatchee formations and the places at which fossils have been collected near Alaqua Creek The numbers on the map are the serial numbers recorded in the station book of the U. S. Geological Survey kept at the National Museum. The boundary between the Shoal River formation and the Choctawhatchee formation as drawn is entirely conjectural. The newly discovered localities are stations 12044–48, 12060, and 12527 The following are the explanations of the station numbers

3742 Shell Bluff Type locality of the Shoal River formation.
3747 Parker place Shoal River formation
4975, 7152 Red Bay Choctawhatchee formation (*Ecphora* zone and upper part of *Arca* zone)
5618 Langley's old farm Shoal River formation
9959 One-fourth mile west of Pleasant Ridge Church Shoal River formation
10612 Chester Spence's farm Provisionally placed in the Shoal River formation.

[1] Published by permission of the Director of the U S Geological Survey and of the State Geologist of Florida Received January 12, 1932

[2] Station 3747, reported by Gardner (U S Geol Survey Prof Paper 142) as 8 miles south of Lake DeFuniak, is 8 miles nearly due west of DeFuniak Springs, in SW ¼ sec 34, T 3 N, R 20 W—an error of the clerk in copying the station record The shells were found at a depth of 30 feet in a well dug for water.

12044	Bell farm, upper locality	Choctawhatchee formation (*Arca* zone)
12045	Bell farm, lower locality	Choctawhatchee formation (*Arca* zone)
12046	Vaughan Creek, upper locality	Choctawhatchee formation (*Arca* zone).
12047	Vaughan Creek, lower locality	Choctawhatchee formation (*Arca zone*)
12048	Permenter's old place	Choctawhatchee formation (*Ecphora* zone)
12060	Frazier's old farm	Choctawhatchee formation (*Yoldia* zone)
12527	Alice Creek	Choctawhatchee formation (upper part of *Arca* zone)

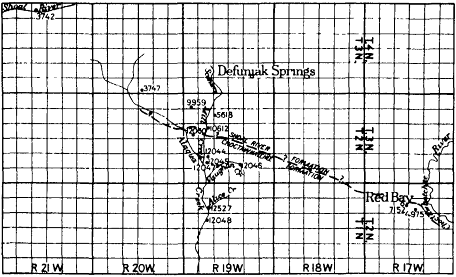


Fig 1 Fossiliferous localities in Walton County, Florida

The most southerly locality in the valley of Alaqua Creek at which fossils had previously been collected is the Chester Spence farm in the NE ¼ sec. 17, T. 2 N., R. 19 W (U S G S station 10612). The fauna at this place appears to be transitional from that of the Shoal River formation to that of the Choctawhatchee formation This fauna is provisionally left in the Shoal River formation, where it was placed by Gardner; but it may eventually be placed in the basal part of the Choctawhatchee formation.

The following generalized section shows the divisions that are now recognized in the Choctawhatchee formation

GENERALIZED SECTION OF THE CHOCTAWHATCHEE FORMATION

			Feet
5	*Cancellaria* zone	Fine to coarse clayey fossiliferous sand	25–30
4	"Aluminous clay"	Grayish unfossiliferous clay	25
3	*Ecphora* zone	Sandy fossiliferous clay	15–25
2	*Arca* zone	Gray sandy fossiliferous marl	55
1	*Yoldia* zone	Dark-gray to bluish micaceous and carbonaceous clayey fossiliferous sand	15

The *Yoldia* zone, which is here recognized for the first time, and the *Arca* zone are now regarded as representing the upper part of the middle Miocene, the *Ecphora* zone, the "aluminous clay," and the *Cancellaria* zone are referred to the upper Miocene.

Yoldia zone.—A new name, *Yoldia* zone, is here proposed for a bed carrying many individuals of the genus *Yoldia* The type locality is the Frazier farm (formerly the Spencer farm), Walton County, in SE ¼ sec 18, T 2 N, R 19 W (station 12060) The sediments composing the zone consist of dark-gray to bluish micaceous clayey sand with inclusions of carbonaceous particles The thickness has not been accurately determined, but it probably does not exceed 15 feet.

The zone is believed to represent the basal bed of the Choctawhatchee formation although the contact with the underlying Shoal River formation which may be conformable with it has not been recognized with certainty The zone is separated from the overlying *Arca* zone because of its abundant content of large *Yoldia* shells, a genus which usually indicates that the temperature of the water in which it lived was rather cold.

Arca zone—The name *Arca* zone was proposed by Mansfield[3] in 1929. The zone is typically exposed at Red Bay, Walton County, where it forms the lowermost fossiliferous bed, about 21 feet thick, in the exposure (stations 4975, 7152). A nearly unfossiliferous upper bed of clay at this locality, which was formerly included in the *Arca* zone, is now placed in the *Ecphora* zone.

The *Arca* zone consists mainly of very fossiliferous gray sandy marl having an estimated total thickness of about 55 feet. It probably rests conformably upon the *Yoldia* zone. The upper limit of the *Arca* zone is provisionally placed at the contact of the marl with an overlying plastic clay bed which, in the section at Red Bay, carries no determinable fossils The shells in the marl are worn and broken.

[3] W C MANSFIELD in C W COOKE and STUART MOSSOM, *Geology of Florida*, Florida Geol Survey Ann Rept 20 140 1929, and W C MANSFIELD, *Miocene gastropods and scaphopods of the Choctawhatchee formation of Florida*, Florida Geol Survey Bull 3: 15 1930

The absence of fossils from the clay and the lithologic difference between the marl and the clay suggest an unconformity between the two beds, but this relationship has not been fully established

The *Arca* zone was observed in the Alaqua Creek Valley at the head of small branches flowing into Sconiers Mill Creek, on the Bell farm, in the NE.¼ sec. 29, T 2 N., R. 19 W (stations 12044-45), on Vaughan Creek, in secs 27 and 28, T. 2 N, R 19 W (stations 12046-47), and at Alice Creek, in the SE.¼ sec 8, T 1 N, R 19 W (station 12527)

The beds exposed at the Bell farm and along Vaughan Creek are believed to carry the earliest fauna of the *Arca* zone, whereas the lower fossiliferous bed at Red Bay carries the latest fauna of this zone. The senior author, basing his evidence upon the study of the mollusks, believes the beds at the Bell farm and along Vaughan Creek have nearly if not the same stratigraphic position, but the junior author, basing his evidence upon the study of the foraminifera, is inclined to believe that the beds along Vaughan Creek are lower in the section than those at the Bell farm.

Ecphora zone—The *Ecphora* "bed," named by Dall and Harris,[4] is now known as the *Ecphora* zone[5] Its type locality is at Alum Bluff, Apalachicola River, Liberty County, Fla, where it forms the uppermost fossiliferous bed of the section The sediments composing the zone consist of a sandy clay which is bluish where unweathered The bed ranges in thickness from 15 to 25 feet at Alum Bluff.

At Alum Bluff the *Ecphora* zone, with somewhat doubtful unconformable relations, rests upon a fossil leaf-bearing sand which Cooke and Mossom[6] questionably refer to the Alum Bluff group It is conformably overlain by the "aluminous clay" of Dall

An exposure in the east bank of Alaqua Creek on Permenter's old place, in sec 17, T. 1 N., R. 19 W. (station 12048) apparently represents the *Ecphora* zone. At Red Bay the upper poorly fossiliferous plastic clay bed, about 27 feet thick, is placed in this zone.

The "aluminous clay."—The "aluminous clay," a name applied by Dall[7] to a 25-foot bed of grayish clay overlying the *Ecphora* zone at Alum Bluff, Liberty County, Fla, has not been recognized in the Alaqua Creek Valley.

[4] W H DALL and G D HARRIS, *The Neocene of North America*, U S Geol Survey Bull **84**: 123–124 1892

[5] W C MANSFIELD in *Geology of Florida*, p 140, 1929

[6] C W COOKE and STUART MOSSOM, *Geology of Florida*, Florida Geol Survey Ann Rept **20**: 108 1929

[7] W H DALL and JOSEPH STANLEY-BROWN, *Cenozoic geology along the Apalachicola River*, Geol Soc Am Bull **5**: 168–169 1894

Cancellaria zone.—The name *Cancellaria* zone was proposed by Mansfield[8] to include beds that carry the latest Miocene fauna. This zone is typically exposed in the highest fossiliferous beds along Harveys Creek, in the SW.¼ sec 9, T. 1 S, R. 3 W, Leon County, Fla. The *Cancellaria* zone is composed of fine to coarse grained clayey sand replete with fossils, having an estimated total thickness of 25 to 30 feet. It has not been recognized in the Alaqua Creek Valley.

BOTANY.—*New species of slime molds.*[1] G W. MARTIN, State University of Iowa. (Communicated by WILLIAM R. MAXON.)

In the present paper six species of Myxomycetes are described as new,—one from Colombia, one from Ontario, and four from the western United States. The descriptions of the two species of *Cribraria* are based in part upon the monographic study of the genus made by Miss Eunice Lovejoy and filed, as a thesis, in the library of the State University of Iowa. The type specimen of the Colombian species and portions of the type specimens of the others are deposited in the United States National Herbarium.

Badhamia cinerascens Martin, sp nov

Peridia sessilia, globosa vel leniter depressa, 0 7–1 5 mm lata, agglomerata, tunica tenuis, fragilis, cinerea, rete calcifero obducta, capillitium album, sporae liberae, fuscae, valide echinulatae, 12–15 μ diam

Sporangia globose or flattened, sessile or occasionally borne on a pallid, membranous stipe, 0 7–1 5 mm in diameter, densely aggregated and more or less superimposed, on a pallid membranous hypothallus, peridium thin, fragile, ashy, covered by a dense network of calcareous thickenings, capillitium abundant, white, badhamioid under lens, but under the microscope exhibiting numerous threadlike tubules, spores intensely black in mass, spherical, non-adherent, deep blackish brown by transmitted light, densely and strongly spinulose, 12–15 μ, averaging 13 5 μ, 2 μ representing the spiny margin

COLOMBIA On tree trunk, La Sierra, Antioquia, alt 2,000 m, March 8, 1931, *W A Archer* 1662 (type, U S Nat Herb)

Close to *B macrocarpa* and, like that and related species, with a more or less physaroid capillitium, but distinguished by its ashy color, the heaped sporangia, and the extremely dark, coarsely and densely spiny spores In appearance not unlike some specimens of *Physarum cinereum*, but the capillitium distinctly more badhamioid than physaroid, and the spores much larger, darker, and rougher

[8] W C MANSFIELD in *Geology of Florida*, p 140 1929

[1] Received December 30, 1931

Amaurochaete ferruginea Macbr. & Martin, sp nov.

Aethalium pulvinatum, longitudine 7 cm , peridium fugaceum, capillitium ferrugineum, sporae ferrugineae, minute verrucosae, 7 5–9 μ diam

Aethalium pulvinate, flat, up to 7 cm in length and 4 cm in width, peridium fugaceous, hypothallus shining, silvery, extending somewhat beyond the margin of the aethalium, definite columellae lacking, but capillitium branching from numerous rigid irregular branches arising from the hypothallus and soon dissipated into subordinate branches, threads dark brown, bearing numerous lighter brown irregular membranous expansions, spores cinnamon-drab to benzo-brown (Ridgway) in mass, pale reddish brown by transmitted light, minutely warted, 7 5–9 μ

CALIFORNIA On charred coniferous wood, Yosemite Park, Aug 31, 1905, *T H Macbride* (type, in herb State Univ Ia , no 1438) OREGON On decorticated coniferous wood, S U I 1139

The structure of the capillitium is very similar to that of *A fuliginosa*, from which species this differs in the brownish color of the capillitium and in the small, pale, relatively smooth, ferruginous spores, the two characters together giving the fructification a ferruginous cast in marked contrast to the black of the other species of the genus

Amaurochaete trechispora Macbr & Martin, sp nov

Aethalium pulvinatum, longitudine 7 cm , peridium obscurum, nitens, fugaceum, tuberculatum, capillitium nigrum, sporae atroviolaceae, reticulatae, 13–15 μ diam

Aethalium pulvinate, flat, up to 7 cm in length, cortex dark, shining, evanescent, faintly tuberculate as though suggesting the tips of component sporangia, hypothallus broadly expanded, persistent, extending well beyond the borders of the aethalium, silvery, with yellowish stains, and amber globules representing remnants of the presumably yellow plasmodium, capillitium black, irregular, composed of numerous stout columella-like bases, these soon becoming dissipated into numerous freely anastomosing branches, peripheral nets lacking, spores purplish black in mass, lilaceous brown by transmitted light, globose, ornamented with a pronounced reticulation formed of wing-like ridges, the meshes coarse and often unequal, 13–15 μ in diameter, 10–12 μ representing the diameter of the body of the spore, the balance the ridges of the reticulum

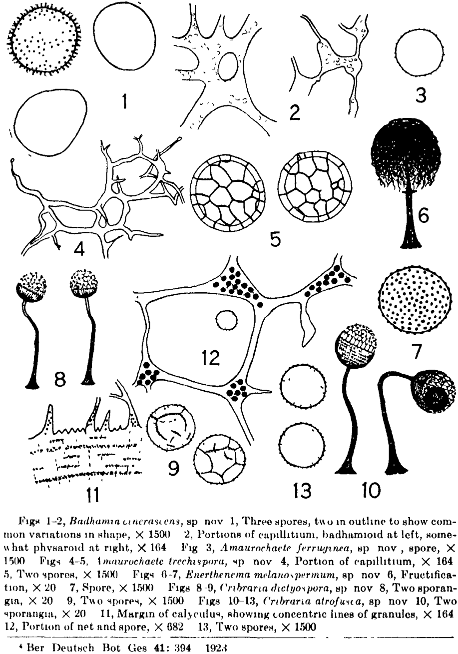
ONTARIO On *Sphagnum*, Temagami Forest Reserve, Oct 6, 1919, *I H Faull* (type, in herb Univ Toronto, no 5135), on herbaceous stem, Aug 14, 1931, *H S Jackson* (herb Univ Toronto 2460)

A well-marked species, related to *A fuliginosa* but separated by its remarkable and striking spores Based on a collection well described by Miss Currie[2] and by her doubtfully referred to *Stemonitis fusca* Roth var *trechispora* Torrend Aside from the reference to the strongly reticulated spores and the occurrence on *Sphagnum*, there is nothing in Torrend's brief description of his variety[3] to suggest the present species, nor can it be the form

[2] Trans Royal Can Inst **1919** 296

[3] Fl Myx 141 1909

described and illustrated by Jahn[4] as *Stemonitis trechispora* Torr It is clearly an *Amaurochaete*



Figs 1–2, *Badhamia cinerascens*, sp nov 1, Three spores, two in outline to show common variations in shape, × 1500 2, Portions of capillitium, badhamioid at left, somewhat physaroid at right, × 164 Fig 3, *Amaurochaete ferruginea*, sp nov, spore, × 1500 Figs 4–5, *Amaurochaete trechispora*, sp nov 4, Portion of capillitium, × 164 5, Two spores, × 1500 Figs 6–7, *Enerthenema melanospermum*, sp nov 6, Fructification, × 20 7, Spore, × 1500 Figs 8–9, *Cribraria dictyospora*, sp nov 8, Two sporangia, × 20 9, Two spores, × 1500 Figs 10–13, *Cribraria atrofusca*, sp nov 10, Two sporangia, × 20 11, Margin of calyculus, showing concentric lines of granules, × 164 12, Portion of net and spore, × 682 13, Two spores, × 1500

[4] Ber Deutsch Bot Ges **41**: 394 1923

Enerthenema melanospermum Macbr. & Martin, sp nov

Peridia stipitata, sphaeroidea vel ovata, nigra, 0 8–1 mm lata, 2 mm alta, stipes niger, crassus, sub apicem attenuatus, sporae atro-olivaceae, crassiter verrucosae, 12–14 μ diam

Sporangia intense black, gregarious in small clusters of three to a dozen, these in larger aggregations, globose or oval, stalked, 0 8 to 1 mm in diameter, total height 2 mm or more, stipe black, shining, rather stout, attenuate upward and continued as a slender unbranched columella capped with a very large, shining, infundibuliform terminal disk, up to 0 5 mm in diameter, capillitium dense, black, rather freely branched, arising from terminal disk and with ends free, spores free, dark olivaceous, coarsely warted, 12–14 μ

OREGON Three Sisters Mountain, *T H Macbride* (type, in herb State Univ Ia, no 1437)

Obviously close to *E papillatum*, but clearly distinct by reason of its large size, the intense and permanent black color, the very large apical disk, and the large, dark, very rough spores

Cribraria dictyospora Martin & Lovejoy, sp nov

Peridia globosa, erecta, atrofusca, 0 4–0 8 mm lata, calyculus partem tertiam peridii occupans, margine denticulatus, nodi crassi, atri, sporae violaceae, coacervatae, ochraceo-brunneae, minute verrucosae et amplter reticulatae, 8–8 8 μ diam

Sporangia gregarious, dark purplish brown, erect or slightly nodding, globose, 0 4–0 8 mm in diameter, total height 1–2 mm, calyculus occupying about one-third of the spore case, marked with irregular, dark, granular rays, the margin toothed, net rather fine-meshed, the connecting threads narrow, the nodes flat and angular, not greatly thickened, densely filled with large, dark granules, making them appear black, free ends abundant, often branched, arising both from nodes and from connecting threads, stipe slender, two or three times the diameter of the sporangium, furrowed, light at the apex, otherwise dark, spores ochraceous brown in mass, clear violet by transmitted light, globose or somewhat angular, minutely warted, and covered with a coarse and often imperfect reticulum of three to five meshes to the hemisphere, 8–8 8 μ, averaging 8 5 μ

OREGON On dead wood, other collection data lacking (type, in herb State Univ Ia, no 1435) A different collection, also from Oregon, herb S U I 1436

No. 1435, designated as the type, is the more ample collection The sporangia are slightly smaller than those of no 1436, the stalks relatively longer, the spores a trifle larger (averaging 8 5 μ as compared with 8 3 μ) and the reticulations slightly less conspicuous They are, clearly, slightly different aspects of the same species

The most striking characteristic of this species is the reticulation of the spores, otherwise unknown in the genus The nodes are similar to those of *C macrocarpa*, but the granules with which they are filled are larger and much darker The margin of the calyculus, with its granular rays, suggests that of *C piriformis*.

Cribraria atrofusca Martin & Lovejoy, sp. nov.

Peridia globosa vel obovata, atrofusca, nitentia, 0 4–0 6 mm lata, erecta, calyculus partem dimidiam peridii occupans, intus concentricus, margine denticulis longis praeditus, nodi dilati, granulati, sporae atrofuscae, tenuiter verrucosae, 7 5–8 5 μ diam

Sporangia loosely gregarious, dark purplish brown to nearly black, shining, iridescent, globose or somewhat obovate or occasionally pyriform, usually erect, 0 4–0 6 mm in diameter, total height 1 2 mm or more, calyculus occupying nearly or quite one-half of spore case, marked by slender granular ribs radiating from the stipe and by broken concentric granular thickenings deposited on the inside, the concentric character being visible without under the lens in brilliant light, the margin with very fine teeth and long, slender toothlike projections, these bearing the net and similar to its nodes, net regular, with broad connecting threads, the nodes expanded, granular, dark brown, with a few free ends arising from both nodes and threads, the silvery peridium tending to persist, hypothallus small, stipe dark brown or nearly black, slender, furrowed, 0 6–1 8 mm long, spores dark reddish brown in mass, grayish brown by transmitted light, finely verrucose, 7 5–8 1 μ, averaging 7 9 μ

COLORADO On coniferous wood, *T H Macbride* (type, in herb State Univ Ia, no 1103), on coniferous wood, *E Bethel*, S U I 1449, on coniferous wood, 1909, *E Bethel*, S U I 1450, on coniferous wood (locality not given, but probably Colorado), S U I 1451

A notable species The dark, glistening sporangium, the dark spores, and the granular concentric rings within the calyculus are diagnostic The toothlike projections which bear the net are longer and more slender than in any other species, but their structure suggests that they are to be regarded as elements of the net rather than of the calyculus The peridium tends to be more persistent than in most cribrarias and in its shining silvery character suggests *Lamproderma arcyrionema* The spores are much the color of some of the more ferruginous species of *Stemonitis*

BOTANY.—*The distribution of* Dictyostelium *and other slime molds in soil*[1] KENNETH B RAPER and CHARLES THOM, Bureau of Chemistry and Soils

In our previous paper (7) it was reported that amoeboid organisms were present in abundance in all samples of soil examined. From certain of these samples plasmodia developed indicating that many of these amoeboids represented only a stage in the life cycle of the Myxomycetes The fruiting bodies of *Dictyostelium* belonging to the Acrasieae, a group of organisms related to the Myxomycetes but which do not have a flagellate stage, and which fruit through a mass movement of amoebae instead of the formation of true plasmodia, also developed in cultures from some samples.

[1] Received January 8, 1932

Following this we encountered these organisms so frequently in our cultures and from such varied sources as to indicate that they were more abundant and widely distributed than previous reports showed. Since the genera of the Acrasieae pass the whole of their vegetative period as amoeboids and merely form aggregates in their fruiting phase, their identification even to the group depends upon finding culture methods which enable them to complete their life cycle. Thus the possibility was apparent that *Dictyostelium* and the closely related genus *Polysphondylium* when present might easily be overlooked.

It is equally apparent, that special culture procedures must be used in isolating and identifying these organisms. The methods employed in this investigation have been rather simple. The sample of soil or decaying vegetation was thoroughly ground in a clean mortar and diluted with approximately ten volumes of sterile water. The resulting suspension was then streaked upon freshly solidified mannite agar (Ashby's formula) plates, about four to five drops being used to each plate. Incubation was for two to three weeks at room temperature or in an incubator at 16–18°C. The necessary incubation period at the lower temperature is slightly longer but certain fungi are held in check which at the higher temperature tend to overrun the plates.

The fruiting bodies of *Dictyostelium* when present are easily recognized under low magnifications. They appear very much like fruiting structures of some mucors, but the absence of any mycelium leading away from the base readily identifies them as belonging to the Acrasieae. The stalk is considerably swollen at the base and tapers considerably toward the top. *Polysphondylium*, with its verticillately branched sporophore simulates certain mycelial fungi in appearance but can likewise be readily recognized by the absence of a mycelium. With a compound microscope either is at once identifiable by the peculiar and characteristic structure of the stalk, which is formed of polygonal cells, arising from amoebae during fruiting, piled one on top of the other.

Dictyostelium grows slowly and poorly on mannite agar, hence it is best to transfer as soon as possible to more favorable media. Mannite agar is used in isolating these organisms, not because it is a particularly favorable medium for them, but because it is quite unfavorable to most fungi and some bacteria, which, if a stronger medium were used, would overrun the plates in a very few days to such an extent that fruiting bodies of *Dictyostelium* would not be able to develop or not found if they did develop. Fair growth has been obtained upon hay

infusion, carrot or a weak horse dung decoction agar. Moist hay has been used with some success. But we have found a medium consisting of mannite agar plus rat dung[2] to be most satisfactory. Excellent growth is obtained upon this medium and the organisms are easily kept in culture by transferring every four to five weeks. The cultures tend to die off after prolonged artificial cultivation.

Polysphondylium grows better than *Dictyostelium* upon mannite agar. Good growth is obtained upon hay and mannite-dung agars A weak horse dung decoction agar also gives excellent growth.

Harper used a weak dung decoction in his studies on *Dictyostelium* (2) and *Polysphondylium* (3). Olive (5) employed both dung and peptone agar in his work on the Acrasieae Skupienski (6) grew *Dictyostelium mucoroides* on weak hay infusion agar.

Our interest in these genera was increased when it became evident that their amoeboid phase appeared in samples of soil from widely different areas A survey of a considerable series of soil samples was therefore undertaken This paper is intended to give a brief review of this survey

During this study *Dictyostelium* has been identified in plates from fifteen samples of various kinds collected in Washington, D C, and in nearby Maryland and Virginia. Included in these were samples of decaying vegetation such as leaves of curly dock, leaves and stems of *Erigeron*, stems of ragweed, dead blue grass and feather grass, oak leaves from the forest, leaf mould underlying oak and maple leaves, and dead grass floating in a pond It has been obtained a number of times from soils underlying grass, both at the surface and at a depth of three inches, and from forest soil underlying leaf mould. It has also been isolated from stagnant water.

Samples for this study were collected in some of the eastern states during September, 1931. Both *Dictyostelium* and *Polysphondylium* were identified in, and isolated from a considerable number of these samples. Table 1 best shows the diverse types of samples studied, the substrata upon which the two genera were found and the place of collection.

In the course of other studies, samples of cultivated field soils from a number of western states were collected by this laboratory during the fall of 1930. They were air dried when collected and remained in this condition in the laboratory. Almost a year later, in September and October, 1931, some of these soils were plated on mannite agar in

[2] Mannite agar plates to which sterile rat dung is added before the agar solidifies

the usual way, incubated at 18–20°C for three weeks, and studied for presence of these organisms *Dictyostelium* appeared in many of the plates. The results obtained are given according to states. *Dictyostelium* developed in four of ten samples from Utah, in three of seven from Nebraska, in four of ten from North Dakota, in two of six from Colorado, while it was not found in the three samples from Iowa. All of these western soils were definitely alkaline, some even as much as pH 8.40, whereas the eastern soils studied were all more or less acid.

The finding of *Dictyostelium* in so many of these soils was especially interesting as showing that members of this genus are not uncommon in cultivated fields in the plains area but normally constitute a part of the micropopulation It indicates that members of the genus are

TABLE 1

No	Genus Found	Nature of Sample	Place of collection
T4	Dictyostelium Polysphondylium	Rotting wood	Staunton, Va
T5	Polysphondylium	Forest soil and humus	Clifton Forge, Va
T10	Dictyostelium	Forest soil	Johnson City, Tenn
T20	Dictyostelium	Phosphatic soil, field	Lexington, Ky
T28	Dictyostelium	Decomposing leaves, hardwood forest	North Vernon, Ind
T33	Dictyostelium	Forest leaves	Scottsburg, Ind
T37	Polysphondylium	Decaying holly leaves	Leonardtown, Md
T39	Polysphondylium	Pine needles	Leonardtown, Md
T41	Polysphondylium	Soil underlying pine needles	Leonardtown, Md
176B	Dictyostelium	Leaf mould layer, hardwood forest	Plainsville, N Y

widely distributed as soil organisms, presenting much the same picture in these soils as in soils collected in and around Washington, D C. It showed clearly that *Dictyostelium* can retain its viability in spite of prolonged dessication, either as spores or encysted myxoamoebae, microcysts.

Until recently these organisms were reported and considered primarily as coprophilous species, which might occasionally be found growing upon decaying vegetation That view is no longer tenable in view of the studies made by Krzemieniewski (4) who found *Dictyostelium mucoroides* in almost all soils examined, and *Polysphondylium violaceum*, though rarely, in uncultivated soils Similarly, Harper (3) isolated *Polysphondylium violaceum* from soil in the parks of New York City This paper extends these American observations to apply to wide areas.

In our studies, species have not been accurately determined, but all cultures of *Dictyostelium* isolated, with two exceptions, appear to belong to the single species *D. mucoroides*. *Polysphondylium violaceum* is the only species of that genus isolated.

CONCLUSION

Attention is therefore called to species of these genera as constituting a part of the normal microflora of soils and decaying vegetation. They should be taken into account in any soil population studies. Although the forms thus far recognized do not account for all of the amoeboid forms found in soil and decaying vegetation of various kinds, they undoubtedly, as shown here, do account for many. Improved culture methods may enable us to identify still more of the "soil amoebae" as belonging in the slime mold group.

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SCIENTIFIC NOTES AND NEWS

Dr T W Stanton has been appointed Chief Geologist of the U S Geological Survey, effective February 1

Col C H Birdseye has been reinstated in the U S Geological Survey as a principal engineer and entered upon that duty February 1 He will serve for the present as consultant to the engineering branches and the Director

Announcement has been received from the permanent committee of the International Congress of Zoology that in accordance with the resolution voted by the 11th Congress at Padua in September, 1930, and after obtaining consent from the Portuguese authorities, the 12th International Congress will be held at Lisbon during the summer of 1935, under the presidency of Dr Arthur R. Jorge, Professor in the University of Lisbon and Director of the Musée Bocage.

Dr. F H H Roberts, Jr, archaeologist in the Bureau of American Ethnology, has been detailed to the Carnegie Institution of Washington to serve as consulting archaeologist in connection with the Carnegie's excavations at Chichen Itza Doctor Roberts sailed from New York on February 2, and will not return until after the first of March.

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CHEMISTRY.—*Hydration of the solute ions of the lighter elements.*[1]

L. H. FLINT, Bureau of Plant Industry. (Communicated by G. N. COLLINS.)

INTRODUCTION

The researches carried out by Jones and his collaborators in the Chemical Laboratory of the Johns Hopkins University over a period of years and reported in various papers,[2] developed several independent lines of evidence, each of which pointed to the existence of hydrates in aqueous solutions. These researches may be said to constitute one of the fundamental bases of a relationship which in subsequent years has become widely recognized as an intimate one. At the present time the validity of a relationship between solute ions and their solvent is scarcely to be questioned.

The relationship between solute ions and solvent appears to be one of attraction, somewhat comparable with that characterizing many electrolytes crystallizing out of saturated solutions under certain conditions to form hydrated crystals. In the latter instance, however, a definite and usually integral number of water molecules is recognized as incorporated with each salt molecule. The relationship in both cases is termed hydration, but our knowledge of the specific molecular values involved in solutions is not sufficient to permit any precise evaluation corresponding with the use of the term as applied to crystals

As a matter of fact we can find little satisfaction in our knowledge of the hydration of solute ions. We may observe that the velocity of a solute ion is not what we had expected it would be,—and may say that the ion is hydrated. We may note that a solute ion does not

[1] Received December 18, 1931

[2] Amer. Chem Journ **23**: 89, 1900; **31**: 303, 1904; **33**: 584, 1905, **37**: 126, 1907 Carn Inst Wash Pub **60**: 80, 1907; **180**: 1913, and others.

depress the solubility of gases to the extent anticipated,—and may say that the ion is hydrated. We may find other real or apparent inconsistencies,—and attribute the results to the hydration of the ions. In resorting to the generalization we may often be correct,—but our explanation can scarcely become productive until our information is sufficient to permit mathematical expression.

Following a study of the hydration of ions over a period of several years, the writer has become convinced that a better understanding of this subject holds much of promise for the establishment of a more satisfactory interpretation of various inter-related solution phenomena. In outlining some of the reasons for such a conviction as a possible contribution to the subject it will be necessary to make two simple assumptions at the outset. These are (1) an inverse integral relationship between the anhydrous weight of a solute ion and the degree of its hydration, and (2) an orderly change in weight accompanying ionization. There are obvious objections to both these assumptions, and the objections may be sustained throughout the inquiry. Nevertheless, some of the suggested relationships which appear to follow the assumptions are of more than passing interest. A number of such relationships touching upon the characteristics of the solute ions of the lighter elements will be considered in this paper.

Electrical Conductivity as an Index of Velocity and Hydration

Following the first assumption we may examine the observed electrical conductivities of simple solute element ions of the lighter elements and obtain the order of hydration indicated by the relative velocities of the ions. With univalent ions such as Na^+ and K^+ the conductivities and velocities may be considered to be of the same order, and through the extension of Graham's Law the relative velocity values of the ions Na^+ and K^+ (as derived from observed measurements of conductivity through the use of transference data) become indices of relative hydration. The assumption of hydration on an inverse integral basis requires that a succession of weight values be characterized by regular intervals. Such a requisite regularity does not characterize the observed combining weights of the lighter elements, but is found in their atomic numbers. These numbers may be brought to the $O = 16$ scale by doubling, in which case a tentative series of regular weight values is attained as a basis upon which to project an assumed inverse integral hydration. The following con-

ductance values for the ions Na^+ and K^+ at 18°C. are given by Nernst.[3] $K^+ = 65.3$, $Na^+ = 44.4$. These values, considered as relative velocities, permit the assumption of an inverse integral hydration only when the weight 38, representing potassium, has four water molecules attached, and the weight 22, representing sodium, has twelve water molecules attached. The weight, hydration and velocity values which

TABLE 1.—WEIGHT, HYDRATION AND VELOCITY VALUES CALCULATED FOR THE LIGHTER ELEMENTS THROUGH AN EXTENSION OF GAS LAWS IN RELATION TO OBSERVED ELECTRICAL CONDUCTIVITIES

A N	E	Assumed as W 2 × A N	V_1	Postulated Number of Water Molecules	Mol Wt Water of Hydration	Mol Wt Hydrated Molecule	V_2
0	—	0	—	23	414	414	491
1	H	2	7082	22	396	398	501
2	He	4	5000	21	378	382	512
3	Li	6	4090	20	360	366	523
4	Be	8	3546	19	342	350	535
5	B	10	3162	18	324	334	547
6	C	12	2887	17	306	318	561
7	N	14	2672	16	288	302	575
8	O	16	2500	15	270	286	591
9	F	18	2357	14	252	270	609
10	Ne	20	2236	13	234	254	627
11	Na	22	2132	12	216	238	648
12	Mg	24	2041	11	198	222	671
13	Al	26	1961	10	180	206	698
14	Si	28	1890	9	162	190	726
15	P	30	1826	8	144	174	758
16	S	32	1768	7	126	158	796
17	Cl	34	1715	6	108	142	839
18	A	36	1667	5	90	126	891
19	K	38	1622	4	72	110	953
20	Ca	40	1581	3	54	94	1031
21	Sc	42	1543	2	36	78	1133
22	Ti	44	1508	1	18	62	1271
23	V	46	1474	0	0	46	1474

thus develop for the lighter elements from the assumed inverse integral relationship in conjunction with observed electrical conductivities are brought together in Table 1.

In Table 1 the first column gives the atomic number of the element, the second column gives the chemical symbol of the element, and the third column gives the atomic number transposed to the familiar O = 16

[3] Citation on page 177 in Bayliss, W M *Principles of General Physiology* 1915

scale as an expression of weight. The fourth column gives the reciprocals of the square-roots of these weight values, multiplied by 10^4 for convenience in manipulation. These reciprocal values represent theoretical relative velocities as derived through the extension of Graham's Law under an assumption of *no hydration*, and on this account they have been designated as V_1 values. The fifth column gives the numbers of water molecules which must be postulated as characterizing hydration when an inverse integral relationship between weight and hydration is associated with the observed relative conductances of potassium and sodium considered as of weight 38 and 22 respectively. The sixth column gives the weight of these water molecules, and the seventh column the total weight of the elements represented as so hydrated. The eighth column gives the reciprocals of the square-roots of these "hydrated weight" values, multiplied by 10^4 for convenience in manipulation. The values of the eighth column represent the theoretical velocities under the indicated hydration as derived through the extension of Graham's Law, and have been designated as V_2 values

The series as above tabulated comprises the elements of the first quarter of the periodic system,—a unique division These elements are hereinafter arbitrarily termed the *lighter* elements as distinguished from the remaining heavier elements of the periodic system.

We may study the possible usefulness of Table 1 by using the second assumption of the paper in connection with it,—namely, the assumption that a regular change in weight accompanies ionization. Under such an assumption the most natural increment of change is that which would be effected by the gain or loss of a unit electrical charge on the nucleus of an atom, by virtue of which the weight characteristic represented in column three of Table 1 would be subject to unit change There are objections to the assumption of a change in weight as an accompaniment of ionization. These objections do not appear to be as serious at present as they would have been before the advent of an electrical interpretation of matter and a knowledge of the modifications characterizing radioactive elements. Nevertheless, the objections to the second assumption may be sustained throughout the inquiry,—notwithstanding which it will be of interest to examine some of the relationships which appear to follow the assumption.

With specific reference to the potassium and sodium ions, K^+ and Na^+, it follows from the above assumption that the regular weight values assigned to the elements, potassium (38) and sodium (22), in

the consideration of their hydration as indicated by relative velocity now become subject to further description as relative weights of the un-ionized or "neutral" elements. These weights as assigned to potassium and sodium further become subject to unit modification for unit charge characterizing the ionized state, and since the potassium and sodium ions being considered have a single positive charge each, it follows that the weights of the so-called "neutral" elements would advance one step upon becoming so ionized. The weight values representing the potassium and sodium ions thus become $K^+ = 40$ and $Na^+ = 24$, and the hydration characterizing these ions as derived from Table 1 is now to be noted as 3 H_2O with K^+ instead of 4 H_2O and 11 H_2O with Na^+ instead of 12 H_2O, the values 4 H_2O and 12 H_2O still representing the indicated degree of hydration characterizing ions of weight 38 and 22 respectively. We now have the K and Na ions with weights modified from the regular values tentatively assigned as prerequisites of an inverse integral hydration relationship and subsequently described as the relative weights of the un-ionized or "neutral" atoms. These modified weights may be further designated as the relative weights of the anhydrous ions, or as "ionic" weights. If the anhydrous ions thus characterized by weight hydrate to the degree corresponding to such a weight, as derived from observed conductivities and indicated in Table 1, it follows that we are now in a position to study the relationship which would have to follow such a hydration system. On the other hand, if the anhydrous ions thus characterized by weight do not hydrate at all, but remain as unhydrated solute ions, it follows that we are also in a position to study the relationships which would have to follow that system In other words, although we are interesting ourselves primarily in a hydration relationship, we are nevertheless in a strategic position to note an absence of hydration, should any solute ions appear from other considerations to be so characterized.

Before taking up the examination of observed measurements in relation to the two fundamental assumptions of this paper and to the hydration system embodied in Table 1 it may be to our advantage to recapitulate with respect to the use of the word "weight." Our first assumption of an inverse integral hydration required a regular system of weight values. Since the observed *combining weights* did not afford such a system the atomic numbers were doubled to obtain a tentative series of weight values later designated as the relative weights of the un-ionized or "neutral" atoms. Our second assumption of an orderly

change in weight accompanying ionization gave us new values designated as relative weights of the ions, or "ionic" weights. It is to be noted that neither the weights of the "neutral" atoms nor the weights of the ions correspond to the weights characterizing the atoms in combination and commonly designated as the combining weights of the atoms, or more simply, the atomic weights. The possible interrelations of the three designations of weight will be considered at a subsequent point.

We may now turn our attention to the study of the possible usefulness of Table 1 in the prediction of solution characteristics. It immediately becomes evident that in the event the indicated numbers of water molecules combine with the respective element-ions to form hydrated ions, *the transfer of such water from the solvent to the solute must profoundly influence the concentration of ions thus hydrated.* Jones and his co-workers recognized this fact, but they were without a tentative basis for evaluating the extent of the influence. Table 1 affords such a basis.

The molecular weight values of the hydrated ions of the lighter elements may be readily derived from column seven of Table 1. For example, the molecular weight of the ion K^+ when hydrated may be derived as follows:

$$K = 38, K^+ = 38 + 2 = 40, K^+ \text{ hydrated} = K^+ + 3\,H_2O = K^+ + (3 \times 18) = 94$$

From the summation weights of the ions characterizing a solution of any electrolyte comprising such ions, the extent of the influence of the assumed hydration may be mathematically calculated. For example, the relative amounts of solvent and solute characterizing a 1.0 molecular solution of KCl would be derived as follows:

$K = 38$, $K^+ = 40$, K^+ hydrated $= K^+$ (40 gms.) $+ 3\,H_2O$ (54 gms.) $=$ hydrated K^+, 94 gms.

$Cl = 34$, $Cl^- = 32$, Cl^- hydrated $= Cl^-$ (32 gms.) $+ 7\,H_2O$ (126 gms.) $=$ hydrated Cl^-, 158 gms.

94 gms. hydrated K^+ + 158 gms. hydrated Cl^- = 252 gms. solute.

In a solution 1.0 molecular made up to 1000 grams, the amount of solvent present would be calculated as $1000 - 252 = 748$ gms., or 74.8% of the amount present at "zero" concentration of solute. In a solution 1.0 molecular made up to a liter with observed combining

weights the concentration would be 1.035 on the above basis by virtue of an observed weight of 74.553 as compared with a calculation weight of 72. Moreover, the total weight of solution under the observed conditions would not be 1000 grams, since the density of the solution is not that of the solvent. Yet a relationship between combining weights and the assumed weights for "neutral" and "ionized" atoms can not be considered in this paper without involving argument in digression. Furthermore, in some electrical conductivities of concentrated solutions as observed by various investigators the values have been transposed from a volume to a weight basis through "corrections."[4] Under the circumstances in a reconnaissance survey of certain relationships which appear to follow our initial assumptions we may disregard the factors which differentiate the two bases, and entertain a degree of tolerance for approximate agreements.

Through the use of Table 1, then, we have calculated that at 1.0 molecular concentration a solution of KCl contains 74.8% of the weight of solvent which characterizes it at "zero" concentration. The observed specific molecular conductivities of KCl at "zero" and 1.0 molecular concentrations, 18°C., as given by Noyes and Falk,[5] are 130.0 and 96.5 respectively. The relative specific molecular conductivity is thus $96.5 \div 130.0 = .742$, or 74 2%.

The obvious suggestion following the order of agreement noted is that the decrease in specific molecular conductivity with concentration, which is quite generally interpreted as indicating incomplete dissociation of the electrolyte, may in reality be an index of the relative weight of solvent present in a solution of a completely ionized electrolyte.

Yet with respect to observed conductivity measurements such an interpretation leads to the inference that the values for concentration, ranging from 1.0 molecular to "zero" molecular, for example, would involve the use of varying bases. If such should prove to be the case the order of relative specific molecular conductivities of various electrolytes comprising ions of the lighter elements should be predictable from the summations of velocities as given in Table 1, through modification to the extent indicated by the summations of weight values (also given in Table 1) in relation to the amount of solvent present. Thus, the amount of solvent characterizing a 1.0 molecular solution of KCl was calculated above from Table 1, as 74.8%. The summation

[4] For example, see Noyes and Falk Journ Amer Chem Soc , 34: 454, 1912

[5] Previous citation.

TABLE 2.—COMPARISON OF OBSERVED SPECIFIC MOLECULAR ELECTRICAL CONDUCTIVITIES OF SOME ELECTROLYTES INVOLVING IONS OF THE LIGHTER ELEMENTS WITH VELOCITY, HYDRATION AND WEIGHT CONSIDERATIONS EMBODIED IN TABLE I

Electrolyte	Observed Weight of Variant Ion of Series	Assumed Weight of Anhydrous Ions (From Table 1)	Assumed Hydration of Ions (From Table 1)	Assumed Weight of Hydrated Ions (From Table 1)	Calculation(4) for % Solvent at 1 0 mol Concentration	Assumed Relative Velocity of Hydrated Ions (From Table 1)	Calculation for unit molecular Velocity	Calculated Relative Unit Velocity at 1 0 mol conc	Observed(7) Relative Unit sp Mol Cond at 1 0 mol conc	Calculated Relative % Solvent present at 1 0 mol conc	Observed(8) Relative Sp Mol Conductivity at 1 0 mol conc
LiCl	6 94	$Li^+ = 8$ (comb wt = 7) $Cl^- = 32$ (comb wt = 33)	$Li^+ = 19\ H_2O$ $Cl^- = 7\ H_2O$ Total = 26 H_2O	$Li^+ = 350$ $Cl^- = 158$ Total = 508	508 − 40 = 468 1000 − 468 = 532 532 − 1000 = 532, or 53 2%	$Li^+ = 535$ $Cl^- = 796$ Total = 1331	532 × 1331 = 708	708	762	53 2	60 7
NaCl	22 997	$Na^+ = 24$ (comb wt = 23) $Cl^- = 32$ (comb wt = 33)	$Na^+ = 11\ H_2O$ $Cl^- = 7\ H_2O$ Total = 18 H_2O	$Na^+ = 222$ $Cl^- = 158$ Total = 380	380 − 56 = 324 1000 − 324 = 676 676 ÷ 1000 = 676, or 67 6%	$Na^+ = 671$ $Cl^- = 796$ Total = 1467	676 × 1467 = 992	992	988	67 6	67 8
$MgCl_2$	24 32	$Mg^{++} = 28$ (comb wt = 26) $Cl^- = 32$ (comb wt = 33)	$Mg^{++} = 9\ H_2O$ $Cl^- = 7\ H_2O$ $Cl^- = 7\ H_2O$ Total = 23 H_2O	$Mg^{++} = 190$ $Cl^- = 158$ $Cl^- = 158$ Total = 506	1000 − 506 = 494 494 − 1000 = 494, or 49 4%	$Mg^{++} = 726$ $Cl^- = 796$ Total = 1522	506 ÷ 2 = 253 1000 − 253 = 747 747 − 1000 = 747 747 × 1522 = 1137 5	1137 5	1254	49 4	48 7
$AlCl_3$	26 97	$Al^{+++} = 32$ (comb wt = 29) $Cl^- = 32$ (comb wt = 33)	$Al^{+++} = 7\ H_2O$ $Cl^- = 7\ H_2O$ $Cl^- = 7\ H_2O$ $Cl^- = 7\ H_2O$ Total = 28 H_2O	$Al^{+++} = 158$ $Cl^- = 158$ $Cl^- = 158$ $Cl^- = 158$ Total = 632	1000 − 632 = 368 368 − 1000 = 368, or 36 8%	$Al^{+++} = 796$ $Cl^- = 796$ Total = 1592	632 ÷ 3 = 210 66 1000 − 210 66 = 789 3 789 3 ÷ 1000 = 789 789 × 1592 = 1256	1256	1288	36 8	36 4
KCl	39 096	$K^+ = 40$ (comb wt = 39) $Cl^- = 32$ (comb wt = 33)	$K^+ = 3\ H_2O$ $Cl^- = 7\ H_2O$ Total = 10 H_2O	$K^+ = 94$ $Cl^- = 158$ Total = 252	1000 − 252 = 748 748 ÷ 1000 = 748, or 74 8%	$K^+ = 1031$ $Cl^- = 796$ Total = 1827	748 × 1827 = 1367	1367	1367 (base)	74 8	74 2
$CaCl_2$	40 07	$Ca^{++} = 44$ (comb wt = 42) $Cl^- = 32$ (comb wt = 33)	$Ca^{++} = 1\ H_2O$ $Cl^- = 7\ H_2O$ $Cl^- = 7\ H_2O$ Total = 15 H_2O	$Ca^{++} = 62$ $Cl^- = 158$ $Cl^- = 158$ Total = 378	1000 − 378 = 622 622 ÷ 1000 = 622, or 62 2%	$Ca^{++} = 1271$ $Cl^- = 796$ Total = 2067	378 ÷ 2 = 189 1000 − 189 = 811 811 ÷ 1000 = 811 811 × 2067 = 1675	1675	1570	62 2	61 2
KF	19 0	$K^+ = 40$ (comb wt = 39) $F^- = 16$ (comb wt = 17)	$K^+ = 3\ H_2O$ $F^- = 15\ H_2O$ Total = 18 H_2O	$K^+ = 94$ $F^- = 286$ Total = 380	380 − 56 = 324 1000 − 324 = 676 676 − 1000 = 676, or 67 6%	$K^+ = 1031$ $F^- = 591$ Total = 1622	676 × 1622 = 1097	1097	1667	67 6	68 35
KCl	35 457	$K^+ = 40$ (comb wt = 39) $Cl^- = 32$ (comb wt = 33)	$K^+ = 3\ H_2O$ $Cl^- = 7\ H_2O$ Total = 10 H_2O	$K^+ = 94$ $Cl^- = 158$ Total = 252	1000 − 252 = 748 748 ÷ 1000 = 748, or 74 8%	$K^+ = 1031$ $Cl^- = 796$ Total = 1827	748 × 1827 = 1367	1367	1367 (base)	74 8	75 5

of the velocity values corresponding to the molecular weights of the hydrated ions K and Cl may be derived from Table 1, column 8, as follows:

$$K = 38, K^+ = 40, K^+ \text{ hydrated} = 40 + 3 H_2O, V_2 = 1031$$
$$Cl = 34, Cl^- = 32, Cl^- \text{ hydrated} = 32 + 7 H_2O, V_2 = 796$$

Summation = 1827

If, now, we represent the specific molecular conductivity of KCl at "zero" concentration by the summation velocity value 1827, at 1.0 molecular concentration the apparent relative velocity value may be calculated as 74.8% of 1827, or 1367, since the transfer of water from solvent to solute under the assumed inverse integral hydration system would reduce the apparent concentration of solvent, as previously noted.

We may now examine a group of electrolytes involving ions of the lighter elements with respect to the above suggestions and the assumed interrelations of weight, hydration and velocity embodied in Table 1. To facilitate such an examination the respective data are brought together in Table 2.

In Table 2, the electrolytes in the respective series are arranged in the order of the increasing atomic weight of the variant ion, as indicated in the second column. In such series the assumption of an inverse integral relationship between weight and hydration would yield relative velocities of an order increasing with weight as calculated

[6] Observed values may involve weight-normal or volume-normal solutions The observed values cited for LiCl, NaCl and KF involved no "correction" to weight-normal basis, and calculations are, therefore, made to correspond with the observed volume-normal basis The other observed values involve "corrections" to the weight-normal basis All observed values in the first series are at 0°C, and in second series at 18°C, except as otherwise noted

[7] LiCl, Jones and Getman, Ztschr phys Chem 46, 1903, p 262, 1 67 m = 42 28, 88 m = 35 58, by interpolation 1 0 mol = 36 597, NaCl, Int Crit Tables, Vol VI, p 233, 1 0 mol = 47 5, $MgCl_2$, Jones, Carn Inst Wash Pub 180, p 65, 9415 m = 60 31; $AlCl_3$ same p 78, 1 0 mol = 61 93, KCl, same p 16, 1 05 mol = 65 7, $CaCl_2$ same, p 16, 1 0 mol = 75 5; KF, Noyes and Falk, J A Chem Soc 34, 1912, p 463, 1 0 mol = 75 95, KCl, same, p 463, 1 0 mol = 98 22

[8] Additional values as follows LiCl, Washburn, J A Chem Soc 33, 1911, p 1474, "zero" conc = 60 3, NaCl, Kohlrausch and Holborn, Leitvermögen der Elektrolyte, 1898, p. 158 [18°C], 1 0 mol = 74 4, 0001 mol = 109 7, $MgCl_2$, Jones, Carn Inst Wash Pub 180, p 65, "zero" conc = 123 95, $AlCl_3$, same, p 78, "zero" conc = 170; KCl, Noyes and Falk [18°C], J A Chem Soc 34, 1912, p 461, "zero" conc = 130 0, p 462, 1 0 mol conc. = 96 5; $CaCl_2$, Jones, Carn Inst Wash Pub 180, p 63, "zero" conc = 123 46, KF, Noyes and Falk, J Am Chem Soc 34, 1912, p 461, "zero" conc = 111 2.

from Table 1 and given in the ninth column. The observed velocities as inferred from the relative unit specific molecular conductivities given in the tenth column are to be noted as of corresponding order. On the other hand, the specific hydration values derived from the above assumption as related to the observed relative ion conductance of the Na and K ions yield an entirely random series of values for the amount of solvent characterizing 1.0 molecular solutions of the respective electrolytes as derived in the fifth and sixth columns and given in the seventh column. The observed relative specific molecular conductivities at 1.0 molecular concentration given in the twelfth column are to be noted as of a corresponding order In the last four columns of Table 2 we have, therefore, a double-checking series of comparisons relating the values of Table 1 to observed measurements. On the one hand relative velocities predicted upon the assumed hydration through the extension of Graham's Law are to be noted as in substantial agreement with observed relative conductivities. On the other hand, the changes in concentration of solvent which would be anticipated from the assumed hydration are to be noted as in agreement with the observed apparent modifications of specific molecular conductivities These interlocking series of comparisons involving two aspects of solution phenomena as measured by electrical conductivity thus appear to be characterized by agreements beyond the possibility of mere accident.

In the third column of Table 2, it may be noted that assumed combining weights are given in parentheses below the assumed weights of the anhydrous ions. These combining weights are intermediate between the respective "neutral" and "ionic" weights previously discussed, and mathematically represent the sharing of electrons in chemical combination, considered from the standpoint of weight-change as an accompaniment of ionization. For example, if the element sodium represented as Na is assigned a weight of 22 in the un-ionized or "neutral" state, and a weight of 24 following the loss of an electron to become positively ionized as Na^+, then when it shares a single electron in combination, its combining weight quite naturally may be assumed as the intermediate value, or 23. The values thereby attained as combining weights for such ions as Li^+, Na^+ and K^+ do not depart appreciably from observed values, but since the corresponding values for many other ions are at variance with observed values the matter of combining weights of the lighter elements requires particular consideration in relation to the assumptions regarding hydration and weight change. If we are to make the two

initial assumptions of this paper it appears incumbent upon us to eventually define combining weight and relate it to a substantial group of observed measurements. At this time, however, the matter of the hydration of the ions must take precedence, and their combining weights must remain parenthetical.

We may now continue the inquiry through an examination of the measurements of other phases of solution phenomena.

Freezing-Point Depression as an Index of Hydration in the Lighter Element Ions

The work of Raoult[9] established an importance for the freezing-point depression of a solvent effected by a solute, and in subsequent years the measurement has become important in the determination of the molecular weights of dissolved non-electrolytes, in the measurement of osmotic pressure of both electrolytes and non-electrolytes and in the measurement of the electrolytic dissociation of electrolytes. As related to each of these applications the usefulness of the measurement appears to be largely restricted to dilute solutions. As related to osmotic pressure the measurement has attained importance through analogy, following the demonstration of a direct proportionality between freezing-point lowering and osmotic pressure. As related to the electrolytic dissociation of electrolytes the measurement attained importance through inference, following the interpretation of the decrease in specific molecular conductivity with increase in concentration as an index of incomplete dissociation.

Yet in the foregoing section observed electrical conductivity values for solutions involving ions of the lighter elements were noted as corresponding with hydration, weight and velocity values predictable from Table 1. The apparent decrease in observed specific molecular electrical conductivity with increase in concentration was suggested as associated with unevaluated changes in concentration caused by the hydration of the ions. The "true" specific molecular conductivity was thus indicated as a constant, whereupon complete ionization at all concentrations became characteristic of all solutions under the initial assumptions of the paper. It will be of interest to study the freezing-point depression of electrolytes involving the lighter element-ions with respect to the considerations embodied in Table 1.

In dilute solutions the depression of the freezing-point of the solvent by the solute is considered proportional to the number of molecules or ions of solute present.

[9] Ann Chem. Phys **28**: 137, 1883; **2**, 66, 1884

We may now examine some observed freezing-point depressions with particular reference to the familiar relationship underlying the interpretation of freezing-point data, namely, that the gram molecular weight of a non-ionizing solute added to 1000 gms. of water reduces the freezing-point by 1.86°C. This relationship is considered as subject to direct modification through ionization, a solute giving rise to two ions, as KCl, effecting a reduction of 2 × 1.86°C., or 3.72°C. and a solute giving rise to three ions, as $CaCl_2$, effecting a reduction of 3 × 1.86°C., or 5.58°C. The degree of agreement between the values postulated under such a relationship and the observed values is commonly interpreted as a measure of dissociation. Yet under the assumptions of this paper electrical conductivities suggest complete ionization at concentrations up to 1.0 molecular KCl or its ionic equivalent.

TWO-ION ELECTROLYTES

Lithium Chloride, LiCl: The following observed values for the freezing-point depression of this electrolyte may be cited[10] 1.0 mol. = 3.80°, .7939 mol. = 2.945°, .5012 mol. = 1.81°, .2474 = 0.86°. The summation weight representing the hydrated solute LiCl at 1.0 mol. concentration as derived from Table 1 is 508, and the proportionate values of the above concentrations may be calculated as follows. 1.0 mol. = 1 × 508 = 508, .7939 mol. = .7939 × 508 = 403.5, .5012 mol. = .5012 × 508 = 254 7; 2474 mol. = .2474 × 508 = 125.8. The observed freezing-point depressions are plotted against these proportionate values in the graph shown in Figure 1 and connected by a heavy line. For comparison we may venture to indicate the freezing-point depression of LiCl when the complete ionization suggested by electrical conductivity measurements is assumed. This depression would be 2 × 1.86°C. (unit molecular depression), or 3.72°C. for a summation weight of an electrolyte forming two ions. The weight value, 508, represents the amount of solute at 1.0 molecular concentration. The values are represented in the graph shown in Figure 1 as a broken line.

Sodium Chloride, NaCl. The following observed values for the freezing-point depression of this electrolyte may be cited.[11] 1.0 mol. = 3.37°, .700 mol. = 2.4°, .4293 mol. = 1.447°, .2325 mol. = .796°.

[10] 1 0 mol from Int Crit Tables, 4: 258 Other values from page 227 in Smithsonian Tables, 6th Edition, 1914

[11] 1 0 mol from Int Crit Tables, 4. 258 Other values from page 227 in Smithsonian Tables, 6th Edition, 1914

The summation weight representing the hydrated solute, NaCl, at 1.0 mol. concentration as derived from Table 1 is 380, and the proportionate values of the above concentrations may be calculated as follows: 1.0 mol. = 1 × 380 = 380; .700 mol. = .700 × 380 = 266, .4293 mol. = .4293 × 380 = 163.2; .2325 mol. = .2325 × 380 = 88.4. The observed freezing-point depressions are plotted against these proportionate values in the graph shown in Figure 1 and connected by a heavy line. The calculated depression for the ionization Na^+

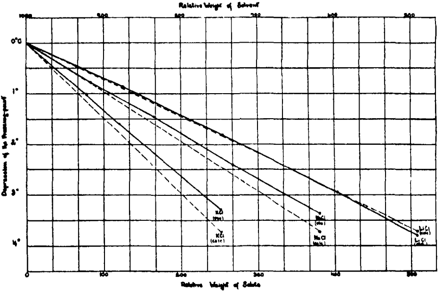


Fig 1 Observed and calculated freezing-point depressions for some two-ion electrolytes

and Cl^- would be 2 × 1.86°C., or 3.72°C. for a summation weight of 380, representing the amount of solute present at 1.0 molecular concentration. The values are represented in the graph shown in Figure 2 as a broken line.

Potassium Chloride, KCl. The following observed values for the freezing-point depression of this electrolyte may be cited [12] 1.0 mol. = 3.268°, .476 mol. = 1.605, .3139 mol. = 1 07. The summation weight representing the hydrated solute KCl at 1 0 mol. concentration as derived from Table 1 is 252, and the proportionate values of the above concentrations may be calculated as follows: 1.0 mol = 1 × 252 = 252; .476 mol. = .476 × 252 = 120, .3139 mol. = .3139 ×

[12] Smithsonian Tables, 6th Edition, p 227, 1914

252 = 79.2. The observed freezing-point depressions are plotted against these proportionate values in the graph shown in Figure 1 and connected by a heavy line. The calculated depression for the ionization K^+ and Cl^- would be 2 × 1.86°C., or 3.72°C. for a summation weight of 252, representing the amount of solute present at 1.0 molecular concentration. The values are represented in the graph shown in Figure 1 as a dotted line.

The comparisons set forth in the graph shown in Figure 1 indicate only a general order of agreement, yet they appear to warrant the

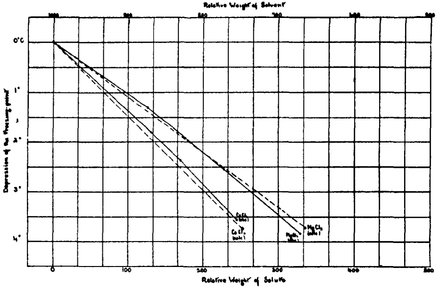


Fig 2 Observed and calculated freezing-point depressions for some three-ion electrolytes

consideration of other electrolytes at corresponding ionic concentrations.

THREE-ION ELECTROLYTES

Magnesium Chloride, $MgCl_2$. The following observed values for the freezing-point depression of this electrolyte may be cited.[13] .65 mol. = 3.854; .45 mol. = 2.537, .35 mol. = 1.910; .25 mol. = 1.306. The summation weight representing the hydrated solute $MgCl_2$ at 1.0 molecular concentration as derived from Table 1 is 506, and the proportionate values of the above concentrations may be calculated

[13] Jones, H. C. Carn. Inst Wash. Pub. 180: 23, 1913.

as follows: .65 mol. = .65 × 506 = 329; .45 mol. = .45 × 506 = 228; .35 mol. = .35 × 506 = 177; .25 mol. = .25 × 506 = 126.5. The observed freezing-point depressions are plotted against these proportionate values in the graph shown in Figure 2 and connected by a heavy line. At .666 mol. concentration, equi-ionic with 1.0 molecular KCl, the calculated freezing-point depression would be $\frac{2}{3}$ × 3 × 1.86°C. = 3.72°C., for a summation weight of .666 × 506, or 337. These values are represented in the graph as a broken line.

Calcium Chloride, $CaCl_2$. The following observed values for the freezing-point depression of this electrolyte may be cited.[14] .65 mol. = 3.55°; .45 mol. = 2.35°; .35 mol. = 1.801°. The summation weight representing the hydrated solute, $CaCl_2$, at 1.0 molecular concentration as derived from Table 1 is 378, and the proportionate values of the above concentrations may be calculated as follows. .65 mol. = .65 × 378 = 245.8; .45 mol. = .45 × 378 = 170, .35 mol. = .35 × 378 = 132.3. The observed freezing-point depressions are plotted against these proportionate values in the graph in Figure 2 and connected by a heavy line. At .666 mol concentration the suggested freezing-point depression would be $\frac{2}{3}$ × 3 × 1 86°C , or 3.72°C., for a summation weight of .666 × 378, or 252. These values are represented in the graph shown in Figure 2 as a broken line.

FOUR-ION ELECTROLYTE

Aluminum Chloride, $AlCl_3$. The following observed values for the freezing-point depression of this electrolyte may be cited [15] .50 mol. = 3.9446°; .4 mol. = 2 910; .25 mol. = 1.6604°; .2 mol. = 1.279. The summation weight representing the hydrated solute $AlCl_3$ at 1.0 molecular concentration as derived from Table 1 is 632, and the proportionate values of the above concentrations may be calculated as follows: .50 mol. = .50 × 632 = 316; .4 mol. = .4 × 632 = 252 8; .25 mol. = .25 × 632 = 158; .2 mol. = .2 × 632 = 126.4. The observed freezing-point depressions are plotted against these proportionate values in the graph shown in Figure 3 and connected by a heavy line. At .50 molecular concentration, equi-ionic with 1.0 molecular KCl, the calculated freezing-point depression would be $\frac{1}{2}$ × 4 × 1.86°C., or 3.72°, for a summation weight of $\frac{1}{2}$ × 632, or 316. These values are represented in the same graph as a dotted line

The order of agreement to be noted in the foregoing graphs indicates

[14] Jones, H C. Carn Inst Wash Pub 180. 22, 1913

[15] Jones, H C. Carn Inst Wash Pub 180· 78, 46, 1913.

that the suggestion of complete ionization at concentrations as great as 1.0 molecular, a suggestion arising from a consideration of electrical conductivity measurements, is not without support in the data of freezing-point determinations. It is readily apparent that at the lower concentrations shown in the graphs the observed freezing-point depressions are less than the calculated values. These differences are substantially off-set when the concentrations of the observed values are recalculated on the weight-normal basis used in apportioning the relative amounts of solute and solvent. It is further apparent from

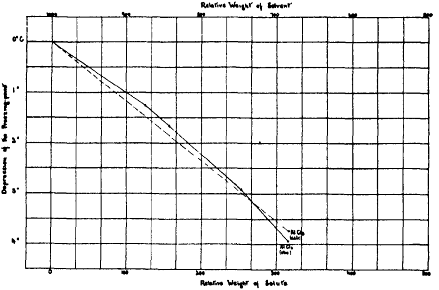


Fig 3 Observed and calculated freezing-point depressions for a four-ion electrolyte

these graphs, moreover, that at concentrations approaching one molecular (for KCl type), or its ionic equivalent, the observed freezing-point depressions of such electrolytes as LiCl, $MgCl_2$ and $AlCl_3$ are greater than those anticipated under the calculated straight-line relationship. These electrolytes are indicated in Table 2 as being characterized by the greater degree of hydration, suggested as a significant factor in the more concentrated solutions. It appears to be of interest, therefore, to examine the freezing-point measurement to the point of solidification of the solution.

A series of freezing-point measurements of solutions of $CaCl_2$ at various concentrations approaching the point at which the solution

solidifies are available from Jones,[16] and on this account this electrolyte will be examined in some detail with respect to hydration.

As derived from Table 1 the anhydrous calcium ion, Ca^{++}, has a weight of 44 (suggesting thereby a combining weight of 42), with a hydration of one water molecule, by virtue of which hydration the hydrated ion has a weight of 62. Similarly, the anhydrous chlorine ion, Cl^-, has a weight of 32 (suggesting thereby a combining weight of 33) with a hydration of seven water molecules, the weight of the hydrated ion being 158. On such a basis, therefore, the summation weights associated with $CaCl_2$ are as follows: anhydrous state, $Ca^{++} = 44$, $Cl^- = 32$, $Cl^- = 32$, total = 108; hydrated state, $Ca^{++} = 62$, $Cl^- = 158$, $Cl^- = 158$, total = 378. We may now calculate a series of characteristics for solutions of $CaCl_2$ at various concentrations on the foregoing basis. Taking 1000 grams of solution as a concentration standard, we may calculate the expected saturation point as follows: $1000 \div 378 = 2.645$. At 2.645 molecular on the weight basis the solution should be saturated, and when concentration is expressed as a weight of electrolyte added to 1000 gms. of water, (which is the basis of concentration used in freezing-point depression studies), and the observed weight of $CaCl_2$ is taken as 111, the 2.645 molecular value becomes 3.605 molecular, or 400 grams $CaCl_2$ added to 1000 gms H_2O. The expected depression of the freezing-point at 2.645 molecular, assuming complete ionization, may be calculated as follows: $2.645 \times 3 \times 1.86° = 14.76°$. But whereas at zero concentration of solute there are 1000 grams of free solvent and anhydrous solute present, at 2.645 molecular concentration of solute there is no free solvent present and 286 gms. of solute. If the freezing-point depression is assumed to have been influenced by this change, the extent of the influence becomes measurable by simple division, in which the relative amount of solvent and anhydrous solute is expressed as a fraction. Thus $14.76° \div .286 = 51.6°$. On such a basis, therefore, we may calculate the expected additional depression of the freezing-point attributable to the transfer of water from solvent to solute under the assumed hydration. A series of values for $CaCl_2$ at various concentrations has been calculated and incorporated in Table 3, wherein is also cited a series of corresponding values from observed freezing-point depressions at various concentrations as obtained by Jones.

[16] Jones, H. C. Carn. Inst. Wash. Pub. 180: 15, 1913.

We may now plot the values of Table 3 relating to proportion of solute and freezing-point depression. In the graph in Figure 4 calculated values appear represented by heavy lines. The straight line is derived from column four of the calculated series, and is an expression of the relationship fundamental to the interpretation of freezing-point depression—1.86°C. depression for each gram ion

TABLE 3.—DATA OF CALCULATED AND OBSERVED FREEZING-POINT DEPRESSION IN RELATION TO AN ASSUMED HYDRATION

Mol Conc (Observed Basis)	Grams Hydrated Solute	Conc Hydrated Solute (Weight Basis)	Calc Freezing-Point Depression (Conc Hyd Sol × 3 × 1 86°)	Grams Free Solvent	Grams Anhydrous Solute	Grams Solvent Plus Grams Anhydrous Solute	Freezing-Point Depression Calculated for conc on Observed Basis,	
CALCULATED SERIES								
0	0	0	0°	1000	0	1000	0°	
5	184	487	2 72°	816	52 6	868 6	3 13°	
1 0	350	926	5 165°	650	100	750	6 89°	
1 5	500	1 323	7 38°	500	142 75	642 75	11 48°	
2 0	636	1 6825	9 385°	364	181 8	545 8	17 22°	
2 5	760	2 01	11 22°	240	217 3	457 3	24 52°	
3 0	876	2 318	12 93°	124	250	374	34 58°	
3 5	980	2 592	14 475°	20	280	300	48 25°	
3 605	1000	2 645	14 76°	0	286	286	51 6°	
OBSERVED SERIES								
								Obs Δ
3	113	299	1 67°	887	32 3	919 3	1 82°	1 517°
7	253	67	3 74°	747	72 2	819 2	4 57°	4 065°
1 0	350	926	5 16°	650	100	750	6 88°	6 41°
1 4	471	1 246	6 95°	529	134 5	663 5	10 48°	10 05°
1 75	569	1 505	8 40°	431	162 6	593 6	14 17°	14 33°
2 2	687	1 8175	10 15°	313	196 5	509 3	19 95°	21 07°
2 7	808	2 138	11 92°	192	232	424	28 1°	30 25°
3 1	896	2 37	13 23°	104	256	360	36 75°	39 5°
3 51	980	2 59	14 45°	20	280	300	48 15°	49 5°

present—although the concentration basis has been modified from "a weight of electrolyte added to 1000 gms. water" to "a weight of electrolyte in 1000 gms. solution." This fundamental relationship thus involves the number of ions present, and in so doing further involves the implication that all solute ions are of the same size—an implication which also follows from the extension of the gas laws in relation to velocity as interpreted through observed electrical conductivities. The curved line derived from column eight of the same

series is an expression of the modification of the straight-line relationship which might be anticipated as a result of the assumed hydration. In other words, under the assumed hydration each molecule of $CaCl_2$ removes fifteen water molecules of solvent, and the unevaluated concentration thereby brought about gives an apparent falling-off in freezing-point depression represented by the departure of the curved line from the straight line.

We may now examine the values for freezing-point depression as derived from column nine of the observed series and represented by a dotted line curve in the graph.

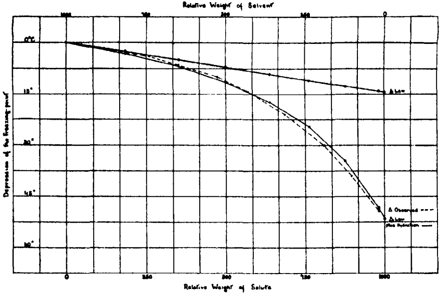


Fig 4 Observed and calculated freezing-point depressions for aqueous solutions of $CaCl_2$ at all concentrations

The agreement between the observed and calculated values as represented respectively by the dotted and full curved lines appears to be beyond the possibility of accident The calculated point at which the mixture of $CaCl_2$ and water becomes 100% hydrated $CaCl_2$ (−51.6°C.) corresponds with the observed cryohydric or eutectic point for $CaCl_2$ in water,[17] which agreement further substantiates the specific hydration assumed. It is of interest to note also that the concentration indicated by the depression 51.6° is 9.25 mol. (51.6 ÷ 5.58 = 9.25). This concentration has the same rela-

[17] Int. Crit. Tables, 4: 257, gives −51°C

tionship to the concentration of hydrated solute, 2.645 mol., as does the initial weight of solvent (1000) to the final weight of anhydrous solute at saturation (286). Since the molecular weight of $CaCl_2$ is involved in the foregoing relationships it is obvious that these freezing-point depression measurements may serve as indices of the weights of calcium and chlorine, the assumed weights being at variance with those commonly observed. As previously noted the matter of combining weight can not be considered in this paper.

The order of agreements above noted with respect to the depression of the freezing-point appears to be in support of the initial assumptions of this paper and the considerations developed through a study of electrical conductivity in relation to them. They appear sufficient, moreover, to warrant a more extended consideration of freezing-point measurements of concentrated solutions, but further studies can not be given space here.

BOILING-POINT ELEVATION AS AN INDEX OF HYDRATION IN THE LIGHTER ELEMENT IONS

The elevation of the boiling-point of any solvent by a solute is commonly considered as proportional to the number of molecules of solute present in a given weight of a solvent. For example, a molecular weight of a solute in grams when added to a liter of water in general raises the boiling-point 0.52°C.,—provided there is no ionization. An increase in the observed elevation over the expected one is interpreted as an index of ionization.

In the foregoing considerations of electrical conductivity and freezing-point depression in relation to an assumed hydration and change in weight, complete ionization of such electrolytes of KCl, LiCl, $CaCl_2$, etc., has been suggested at all concentrations. Consequently on the above basis we would expect that a gram-molecular-weight of KCl, for example, dissolved in a liter of water, would raise the boiling point twice the unit molecular amount, or 1.04°C. Similarly we would expect that a three-ion electrolyte, as $CaCl_2$, would raise the boiling-point 3 × .52°, or 1.56°, while $AlCl_3$ as a four-ion electrolyte would raise the boiling-point 2.08°C.

On the foregoing bases we may compare the calculated and observed elevations of the boiling-point characterizing solutions of electrolytes involving ions of the lighter elements as follows:[18]

[18] References for observed values KCl, NaCl, Jabłczyński and Kon, Jour. Chem. Soc., London **123**: 2953, 1923. $CaCl_2$, Baker and Waite, Chem. and Metallurgical Engineering **25**: 1174, 1921. $MgCl_2$, Kahlenberg, L., Jour. of Physical Chem. **5**: 366, 1901. LiCl, Biltz, Zeit. fur physik. Chemie, **40**: 208, 1902.

TWO-ION ELECTROLYTES

Calculated KCl· Assuming for an approximation that one mole in 1000 parts by weight effects a unit elevation of .52°C , we have KCl, K^+ = 40, mol. wt. hyd. = 94, Cl^- = 32, mol. wt. hyd. = 158, 94 + 158 = 252, total mol. wt. 2 ions, 2 × .52° = 1.04°; *Observed KCl* .8842 m. = .824°, .8842 × 252 = 223. *Calculated NaCl*· Na^+ = 24, mol. wt. hyd. = 222, Cl^- = 32, mol. wt hyd. = 158, 222 + 158 = 380, total mol wt. 2 ions, 2 × .52° = 1 04°, *Observed NaCl* .9208 m. = .888°, .9208 × 380 = 350. *Calculated LiCl.* Li^+ = 8, mol. wt

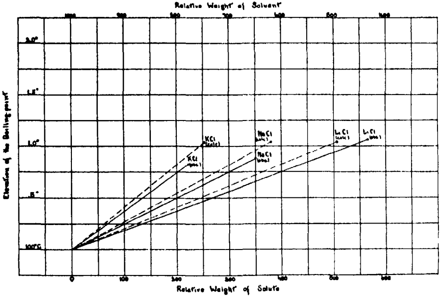


Fig 5 Observed and calculated elevations of the boiling-point for some two-ion electrolytes

hyd. = 350, Cl^- = 32, mol. wt. hyd. = 158, 350 + 158 = 508, total mol. wt. hyd. 2 ions, 2 × .52° = 1.04°, *Observed LiCl* 1 05 m. LiCl gives an elevation of the boiling point of 1.063°C. *Observed Weight* LiCl = 42.48, *Calculated Weight* = 40, 42.48 ÷ 40 = 1.062, 1.062 × 1.05 = 1.115, 1.115 × 508 = 566.

THREE-ION ELECTROLYTES

Calculated $CaCl_2$: Ca^{++} = 44, mol. wt hyd. = 62, Cl^- = 32, mol. wt. hyd. = 158, Cl^- = 32, mol. wt. hyd. = 158, 62 + 158 + 158 = 378, total mol. wt. 3 ions, 3 × .52° = 1 56°. *Observed $CaCl_2$*. 10 gms. $CaCl_2$ added to 100 gms. H_2O, gives boiling point of 101 3°C. Same

as 100 gms. added to 1 liter H_2O, 100 ÷ 1100 = .091 or 91 parts per thousand. 91 + 108 (theo. mol. wt. anhydrous $CaCl_2$) = 318. Elevation effected: 1.3°C. *Calculated $MgCl_2$*: Mg^{++} = 28, mol. wt. hyd. = 190, Cl^- = 32, mol. wt. hyd. = 158, Cl^- = 32, mol. wt. hyd. = 158, 190 + 158 + 158 = 506, total mol. wt. 3 ions, 3 × .52° = 1.56°. *Observed $MgCl_2$*: 9.156 gms. added to 100 gms. water raised boiling point 1.351°C. Equivalent to 91.56 gms. added to 1000 gms. water. 91.56 : 1091.56 :: x : 1000, x = 73.9 (equivalent to 83.9 gms. per 1000 gms. solution), 83.9 ÷ 92 (mol. wt. anhydrous $MgCl_2$)

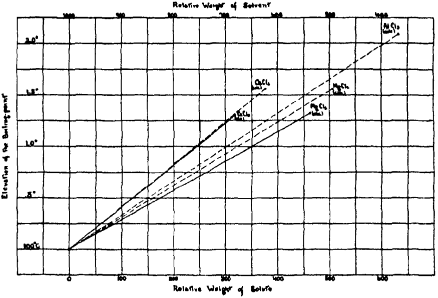


Fig 6 Observed and calculated elevations of the boiling-point for some electrolytes of more than two ions

= .912, .912 × 506 (mol. wt. hyd. $MgCl_2$) = 461.5, relative wt. of hydrated solute.

FOUR-ION ELECTROLYTES

Calculated $AlCl_3$: Al^{+++} = 32, mol. wt. hyd. = 158, Cl^- = 32, mol. wt. hyd. = 158, Cl^- = 32, mol. wt. hyd. = 158, Cl^- = 32, mol. wt. hyd. = 158, 158 (Al^{+++}) + 158 (Cl^-) + 158 (Cl^-) + 158 (Cl^-) = 632, 4 ions, 4 × .52° = 2.08°. *Observed $AlCl_3$*: Corresponding observed values are not readily available at this writing.

An examination of the graphs in Figures 5 and 6 indicates that the calculated and observed values are in substantial agreement, and the

boiling-point measurements to the extent of the agreements thus become subject to interpretation as indicating complete ionization at all concentrations. The data thus appear to support the suggestions of electrical conductivity and freezing-point depression in this regard.

With the addition of more and more solute to a solvent the boiling-point is raised higher and higher. The ratios of solvent to solute brought about by such concentrations suggest that the assumed attraction of the solute for the solvent is gradually offset through the elevation of the temperature. In any case the measurement of boiling-point elevation at high concentrations becomes of interest in relation to the initial assumptions of this paper, but such data are not readily available at present. Until such measurements become available the elevation of the boiling-point appears to be a measurement which can supply only indirect evidence for hydration.

SUMMARY

In the foregoing pages an inquiry has been made into the hydration of the solute ions of the lighter elements. Two initial assumptions were made (1) an inverse integral relationship between the anhydrous weight of a solute ion and the degree of its hydration and (2) an orderly change in weight accompanying ionization. Many observed measurements, involving electrical conductivity, freezing-point depression and boiling-point elevation have been noted as subject to a uniform interpretation on the basis of these assumptions The order of agreement attained appears to warrant the extension of the inquiry to other ions,—a study which will be reported in a subsequent paper.

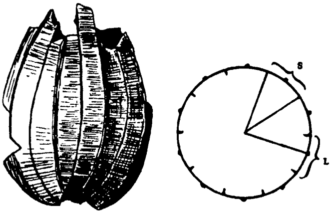
PALEOBOTANY.—*A sterculiaceous fruit from the lower Eocene (?) of Colorado.*[1] EDWARD W. BERRY, Johns Hopkins University.

A unique fossil fruit, which was sent to me for determination some months ago by Professor R. D. George of the University of Colorado, is sufficiently characteristic and important to be placed on record. It seems to be definitely referable to the family Sterculiaceae, which family is abundantly represented by a variety of foliar remains throughout the Upper Cretaceous and early Tertiary, but which becomes restricted to the warmer and more humid regions of lower latitudes after the early Tertiary.

The limited amount of carpological material of recent members of the Sterculiaceae or of allied families of the order Malvales has pre-

[1] Received January 19, 1932

vented me from finding an exact living representative of the fossil assuming that there is such a representative, and I have therefore been constrained to refer it to the form genus *Sterculiocarpus*. This genus was proposed by me[2] in 1916 for fruits belonging to the family Sterculiaceae, but with unknown or uncertain existing representatives. Two species, *Sterculiocarpus eocenicus*[3] and *Sterculiocarpus sezanelloides*,[4] were described, and a third species, *Sterculiocarpus sphericus*, was described[5] in 1930. These were all from the lower Eocene Wilcox group and clearly represented three distinct types which it is difficult to imagine could have come within the limits of a single natural genus.



1 2

Figs 1, 2 —*Sterculiocarpus coloradensis*, natural size

The only other pertinent reference in the literature is a paper by Viguier[6] describing the remarkable flowers and fruits from the lower Eocene travertine of Sézanne in France, which are definitely referable to the tribe Lasiopetaleae of this family, and for which the genus *Sezanella*, with two species was erected.

The present specimen may be described as follows.

Sterculiocarpus coloradensis n sp.

Figs 1, 2.

The single specimen consists of a limonite replacement, whether secondary after siderite, directly from lignite, or a cavity filling is unknown, of a large

[2] EDWARD W BERRY U S Geol Survey Prof Paper **91**: 287 1916

[3] *Idem* 288, pl 74, figs 1–3

[4] *Idem* 288, pl 72, figs 4–6

[5] E W BERRY U S Geol Survey Prof Paper **156**: 109, pl 25, fig 19, pl 48, figs 9–14 1930

[6] R VIGUIER Revue génér bot **20**. 6–13, text fig 1–6, pl 5 1908

spheroidal capsule One longitudinal half is nearly complete and there are parts of nearly all of the base of the opposite side

Form prolate spheroidal, somewhat more fully rounded proximad than distad. Length about 5.25 centimeters Equatorial diameter about 4 centimeters in the plane of flattening and 3 centimeters in the plane at right angles to it. Surface with 10 fairly prominent longitudinal ridges, equally alternating with 10 sulcae The latter may be a living feature but have the appearance of representing lines of dehiscence of a tardily dehiscent capsule The surface is minutely ornamented with fine transverse, subparallel, inosculating, impressed lines, which may be a natural feature, or merely result from the manner of fossilization. Exposed inner faces in the radial planes of the surface sulcae show similar markings, and these are the basis for considering the capsule to have been septicidal

The capsule is divided into 10 compartments and appears to have been ligneous in life. It is possible that the longitudinal ridges of the outer surface represent the exterior edge of the compartment walls, in which case the dehiscence was loculicidal. The first of these alternatives seems the more probable. It is also possible that these ridges represent the position of parietal placentae, but it seems more likely that the placentation was axile I surmise this from rather obscure internal markings which may represent the impression scars of seeds. No structural features other than those mentioned are discernable

An undeformed equatorial cross section is shown in fig 2 and I have indicated on this the alternative interpretations at **S** (septicidal) and **L** (loculicidal).

The single specimen is the property of Cecil Shelton of Kutch, Colorado, and it came from the valley of Big Sandy Creek in Sec 5, T 11 S, R 60 W., 6th principal meridian The country rock here is Laramie, near the Laramie-Dawson contact. Tertiary rocks of Miocene-Pliocene age border the valley on both the north and south sides within a couple of miles. It seems probable that the fossil is of Dawson age, although this is subject to the uncertainty attending the discovery of an entirely new type An early Eocene age is assigned to the Dawson

The only comparable carpological remains, which have already been mentioned (*ante*) come from the lower Eocene of the Mississippi Gulf embayment, and from the lower Eocene of France, but the weight of this is somewhat discounted by the fact that leaves of various types of Sterculiaceae are common as early as the base of the Upper Cretaceous in this general region, where they disappear after Eocene time The present specimen, although differing in size and external form, agrees with *Sezanella* in having ten compartments, septicidal dehiscence, and axile placentae

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

244TH MEETING

The 244th meeting of the Academy was held in the Auditorium of the Interior Department Building, on Wednesday, December 9, 1931 President

N. A. COBB called the meeting to order at 8:15 and introduced the speaker of the evening, Dr E G CONKLIN, Professor of Zoology, Princeton University, who delivered an illustrated address on *Fitness and purpose in the living world* About 270 persons were present.

245TH MEETING

The 245th meeting of the Academy was a joint meeting with the Geological Society of Washington, held in the Auditorium of the Interior Department Building, on Tuesday, January 12, 1932. 150 persons were present. Vice-President H. L. CURTIS called the meeting to order at 8.15 and introduced Dr. F. E. MATTHES who presented Professor F. A VENING MEINESZ of the University of Utrecht, member of the Netherlands Geodetic Commission, who delivered an address on *Gravity results of submarine expeditions in the East and West Indies and their relation to tectonic phenomena.* Doctor VENING MEINESZ has developed a new and accurate method for measuring gravity at sea During the past decade he has travelled 50,000 miles in submarines and has occupied many hundreds of gravity stations at sea. His work is of great importance to geodesy and to our knowledge of isostasy, tectonics, and the shape of the earth

After a brief intermission the address was followed by the 34th annual meeting of the Academy, which was called to order by Vice-President H. L. CURTIS.

The report of the last annual meeting was read by the Recording Secretary and approved. The report of the Corresponding Secretary, PAUL E HOWE, showed the membership of the Academy on January 1, 1932, to consist of 15 honorary members, 3 patrons, and 569 members, one of whom was a life member; a total of 587, of whom 384 reside in or near the District of Columbia, 28 in foreign countries, and 175 in other parts of the continental United States. The members of the Academy stood in respect to the memory of those who had died during the year: EDWARD GOODRICH ACHESON, New York City, July 6, 1931; HENRY MARC AMI, Ottawa, Canada, January 4, 1931; J W. GIDLEY, Washington, September 26, 1931; ALFRED JUDSON HENRY, Washington, October 5, 1931, HOWARD L. HODGKINS, Washington, February 13, 1931, GEORGE MARTIN KOBER, Washington, May 24, 1913, RUSSELL A. OAKLEY, Washington, August 6, 1931; L. H PAMMEL, Ames, Iowa; HENRY MARTIN PAUL, Washington, March 15, 1931, R. A. F. PENROSE, JR, Philadelphia, Pa, July 30, 1931. Honorary Members: F. WIGGLESWORTH CLARKE, Washington, May 23, 1931; RAOUL GAUTIER, Switzerland, April 9, 1931, DAVID STARR JORDAN, Stanford University, September 19, 1931.

The report of the Recording Secretary showed 8 scientific meetings during the year of which three were joint meetings The meetings and abstracts of the addresses given at these meetings, have been filed and published in the Journal of the Academy The report was approved.

The report of the Treasurer, H. G. AVERS, showed $6,712 14 to be accounted for with disbursements of $4,843 45 and a bank balance of $1,868.69 on December 31, 1931 Assets were listed as $23,074.12

The report of the Auditors consisting of approval of the report of the Treasurer, was read and both reports were accepted and filed.

The Senior Editor of the Journal, C. WYTHE COOKE, submitted the following record of the twenty-first year of publication of the Journal:

Volume 21 consists of 552 pages, containing 41 papers by members and

39 communicated papers, and being illustrated by 14 half-tones and 47 line engravings. Relative to the number of pages occupied by them these papers were distributed as follows: 5 mathematical or physical papers, 32.8; 5 papers on chemistry, physical chemistry, or crystallography, 35.6; 14 papers on geophysics, geology, paleontology, or paleobotany, 101 1; 18 papers on botany, 108.5; 35 zoological papers, totaling, 140.6; 3 papers on archeology, ethnology, or necrology, 11.0.

This report was approved.

Mr. O. H. GISH, Chairman of the Teller's Committee, reported 270 ballots counted. The following officers were elected: L. H. ADAMS, *President;* W. F. EICHELBERGER and W. H WILMER, *Non-resident Vice-Presidents;* PAUL E. HOWE, *Corresponding Secretary;* CHARLES THOM, *Recording Secretary,* H. G. AVERS, *Treasurer;* C. WYTHE COOKE and J. A. FLEMING, *Managers* for the term of three years ending January, 1935

The Corresponding Secretary reported the following members as nominated for *Vice-Presidents* by the affiliated societies Upon motion the Secretary was directed to cast one ballot for the election of the list as read: *Anthropological,* Mr N. M. JUDD,[1] *Archaeological,* Dr WALTER HOUGH; *Bacteriological,* Dr. L A. ROGERS; *Biological,* Mr H. H T JACKSON; *Botanical,* Dr. H. B HUMPHREY, *Chemical,* Dr. EDWARD WICHERS; *Electrical Engineers,* Dr EUGENE C CRITTENDEN; *Engineers,* Prof O. B. FRENCH; *Entomological,* Dr. HAROLD MORRISON; *Foresters,* Dr F. C. CRAIGHEAD; *Geographic,* Dr F. V. COVILLE; *Geological,* Mr O. E. MEINZER; *Helminthological,* Dr. G. STEINER; *Historical,* Mr. ALLEN CLARK; *Mechanical Engineers,* Dr H. L. WHITTEMORE; *Medical,* Dr HENRY C. MACATEE, *Military Engineers,* Col. C H. BIRDSEYE; *Philosophical,* Dr. H L CURTIS.

Past President HUMPHREYS was delegated to escort President L H. ADAMS to the chair. President ADAMS addressed the Academy briefly and declared the meeting adjourned at 9.55 P.M.

CHARLES THOM, *Recording Secretary*

RECENTLY ELECTED TO MEMBERSHIP IN THE WASHINGTON ACADEMY OF SCIENCES

HONORARY MEMBER

SIR JAMES HOPWOOD JEANS has been made an Honorary Member in recognition of his contributions to the dynamical theory of gases, to cosmogony, and to astrophysics. His brilliant applications of mathematical physics to the problems of astronomy have made him one of the leaders in the recent great advance in that science. Among his important publications are the following books: *The Dynamical Theory of Gases, Problems in Cosmogony and Stellar Dynamics,* and *Astronomy and Cosmogony* He is a Research Associate of the Carnegie Institution of Washington.

MEMBERS

Dr. FREDERICK SUMNER BRACKETT, director of the Division of Radiation and Organisms, of the Smithsonian Institution Dr BRACKETT is well known for his investigations in spectroscopy, including the development of thermopiles, and for his researches on plants and radiation, the results of which have been published in various journals.

[1] Elected by Board of Managers.

Dr. ROBERT HERMAN BOGUE, research director, Portland Cement Association Fellowship at the Bureau of Standards. Dr. BOGUE was elected to membership in recognition of his contributions to colloid chemistry and to the physical chemistry of silicates. He is the author of numerous papers on these subjects.

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CHARLES ALLEN CARY, Physiological Chemist, Research Laboratories, Bureau of Dairy Industry Mr CARY was elected to membership in recognition of his contributions to the knowledge of nutrition and particularly the protein metabolism of milking cows. He is the author of numerous papers on these subjects.

HENRY B. COLLINS, JR , Assistant Curator, Division of Ethnology, U S. National Museum His election to membership was in recognition of his archeological researches in the southeastern section of the United States and in Alaska, and his contributions to physical anthropology.

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BOTANY.—*The genus* Sanchezia *in Peru.*[1] E. C. LEONARD, U. S. National Museum. (Communicated by E. P. KILLIP).

The genus *Sanchezia*, belonging to the family Acanthaceae, consists mainly of shrubs having large, firm, subentire leaves, which are either bright green or, in a few species, conspicuously variegated along the main veins. The flowers, arranged in spikes or panicles, have tubular, small-lobed, red, yellow, or purple corollas. Inserted at the base of the corollas are two pairs of stamens, one pair long and usually exserted, the other shorter and sterile (staminodes). Floral bracts are present in all the species. In some they are small and inconspicuous, but in others they are large and bright red or yellow. The brilliant color of the inflorescence as a whole, in contrast to the bright green of the leaves, adds greatly to the attractiveness and beauty of these plants. They grow wild in the wet forest regions of the northern Andes, but being easily adaptable to cultivation they have been carried to widely separated countries, where, either as greenhouse plants or escapes, they readily flourish. I have examined such collections from Costa Rica, Cuba, Java, and Amboina.

Since the publication of an earlier paper[2] on *Sanchezia*, a large number of Peruvian specimens have been submitted to me for identification, among these nine undescribed species. It seems well worth while, therefore, to bring together in a single paper descriptions of all the Peruvian species (21) now known. The recent material has been obtained largely through the collecting of E. P. Killip and A. C. Smith, Llewelyn Williams, and Guillermo Klug. Further exploration will doubtless bring to light many additional species in this interesting and complex group.

[1] Published by permission of the Secretary of the Smithsonian Institution Received January 22, 1932

[2] E C Leonard, *Notes on the genus* Sanchezia This Journal, 16: 484–492 1926

KEY TO THE PERUVIAN SPECIES

Calyx lobes lanceolate, slender-acuminate.
  Bracts 6.5 to 7 cm. long . . . . **1. S. filamentosa.**
  Bracts 2 cm. long or less
    Sterile bracts 1 to 1.5 cm. long, 4 to 5 mm. wide; corolla puberulent. **2. S. williamsii.**
    Sterile bracts 4 to 5 mm. long, 1 to 2 mm. wide; corolla glabrous.
      Leaf blades large, up to 25 cm. long and 12 cm. wide, glabrous; staminodes 2.5 cm. long, pilose . **3. S. oxysepala.**
      Leaf blades smaller, up to 11 cm. long and 3.5 cm. wide; staminodes 1.8 cm. long or less, glabrous. . . . . . . **4. S. sprucei.**
Calyx lobes oblong, acute to rounded.
  Bracts small, shorter than the calyx (sometimes exceeding the calyx in no. 5).
    Inflorescence of 1 or more slender unilateral spikes (imperfectly unilateral in no. 5).
      Leaves elliptic, abruptly narrowed at base, less than twice as long as broad; bracts 3 to 6 mm. long . . **5. S. sylvestris.**
      Leaves oblong-elliptic, gradually narrowed to base, more than twice as long as broad; bracts 8 to 25 mm. long.
        Bracts acuminate, 1.6 to 2.5 cm. long, often equaling or exceeding the calyx . . . . **6. S. rosea.**
        Bracts obtuse or acute, 1.5 cm. long or less, much shorter than the calyx.
          Corolla pubescent; calyx segments 1.7 to 2 cm. long; bracts glabrous . . **7. S. loranthifolia.**
          Corolla glabrous; calyx segments 1.4 to 1.6 cm. long; bracts puberulent . . **8. S. tigrina.**
    Inflorescence compact, not unilateral.
      Leaves rounded or obtuse at base; flowers sessile in the axils of the bracts **9. S. conferta.**
      Leaves acute at base; flowers crowded at the ends of the peduncles. **10. S. capitata.**
  Bracts large, longer than the calyx and concealing it.
    Leaves pubescent . . **11. S. ovata.**
    Leaves glabrous.
      Bracts connate at least to middle.
        Lateral nerves 15 to 17 to a side; corolla lobes 5 mm. long. **12. S. cyathibracteata.**
        Lateral nerves 9 to 12 to a side; corolla lobes 3 mm. long. **13. S. pennellii.**
      Bracts not connate.
        Corolla manifestly pubescent.
          Bracts and bractlets pubescent; corolla 4 cm. long or less. **14. S. oblonga.**
          Bracts and leaflets glabrous; corolla 5 to 6 cm. long. **15. S. macbridei.**
        Corolla glabrous, or with a few hairs near the tip of the lobes.
          Leaves gradually narrowed into winged petioles.
            Corolla red, staminodes about 3 mm. long, glabrous above. **16. S. peruviana.**

Corolla yellow; staminodes about 2 cm long, pilose above
17. **S. flava.**

Leaves plainly differentiated into leaf blade and petiole
Corolla red
Leaf blades entire or undulate; staminodes averaging 10 mm. long . 18. **S. rubriflora.**
Leaf blades coarsely crenate-dentate; staminodes averaging 4 mm long . . . 19. **S. pulchra.**
Corolla yellow.
Leaf blades ovate, obtuse or rounded at base, inflorescence capitate or a short congested spike, staminodes glabrous or sparingly pubescent above 20. **S. stenantha.**
Leaf blades oblong, elliptic, or oblong-obovate, narrowed at base, inflorescence spicate; staminodes pilose above.
21. **S. killipii.**

1. **Sanchezia filamentosa** Lindau, Bull Herb Bois II **4:** 314 1904

Stem subquadrangular, pubescent, petioles 3 to 7 cm. long, pubescent; leaf blades ovate, up to 30 cm long, 12 cm wide, obliquely acuminate at apex, slightly narrowed at base, the nerves and midrib pubescent, the cystoliths 0.5 mm long, inflorescence a terminal panicle, the branches unilateral, the bracts opposite, one sterile the other subtending 2 to 4 flowers, bracts and bractlets up to 7 cm. long, 3 to 5 mm wide at base, produced into a long slender tip, calyx segments linear-lanceolate, 3 5 to 6 cm long, 3 to 4 mm. wide at base, pubescent; corolla purple, 4 5 cm long, pubescent toward tip, the lobes 3.5 mm in diameter; stamens and staminodes pubescent at base, pilose above, the staminodes about 2 cm long, slender and narrowly capitate.

Type collected near Pongo de Cainarachi, Department of Loreto, Peru, by E. Ule (no 6401)

No material is available for my examination and the above description has been compiled from the original This species should be easily recognized by its extremely long slender bracts and calyx segments

2. **Sanchezia williamsii** Leonard, sp nov.

Frutex, ramis gracilibus subtetragonis glabris vel pubescentibus; foliis ellipticis vel leviter obovatis basi acutis vel breviter in petiolum decurrentibus, apice acuminatis, margine integerrimis vel undulatis, glabris, nervis fulvo-pilosis exceptis, cystolithis conspicuis, spica interrupta; bracteis lanceolatis pubescentibus dense ciliatis, bracteolis anguste lanceolatis, calycis laciniis anguste lanceolatis; corolla rubra puberula

Shrub; stem slender, quadrangular with rounded angles, glabrous or slightly pubescent at the nodes, petioles 2 to 4 cm long, channeled, glabrous, or pubescent above; leaf blades elliptic or slightly obovate, up to 16 cm. long, 6.5 cm. wide, acuminate at apex, acute at base and subdecurrent on the petioles, entire or undulate, glabrous except the nerves and midrib, these prominent and pilose with yellowish-brown ascending or spreading hairs 0 5 mm. long, the cystoliths 0.25 to 0 5 mm long, prominent and numerous on upper surface, less so on lower, crowded and parallel on nerves and midrib; inflorescence an interrupted spike 10 to 22 cm long, the lowermost internode about 5 cm. long, the others successively shorter toward the summit, all pubescent with ascending hairs up to 1 mm long, bracts lanceolate, 10

to 15 (occasionally 20) mm long, 3 to 5 mm wide (bract subtending the flowers slightly larger than the opposite sterile one), acute or acuminate at apex, pubescent with ascending hairs, densely ciliate, the cystoliths prominent and crowded, flowers one to several, crowded on a short peduncle 1 to 5 mm long; bractlets linear-lanceolate, otherwise similar to the bracts; calyx 2 to 2.8 cm long, the segments linear-lanceolate, 2 to 3 mm. wide, sparingly pubescent without, densely so within, the hairs ascending; corolla (immature) red (?), puberulent, the lobes 2 mm long, 1.5 mm wide, shallowly emarginate; filaments glabrous, staminodes 3 mm long (?), style 4 cm long, glabrous

Type in the U. S. National Herbarium, no. 1,444,810, collected at San Roque, Department of San Martín, Peru, altitude 1,350 to 1,500 meters, January or February, 1930, by Llewelyn Williams (no. 7701). Williams' no. 7215 from the same locality also belongs to this species

This is closely related to *S. oxysepala*, but can be distinguished readily by its simple spike, its denser pubescence, and its larger bracts (10 to 15 mm. long). In *S. oxysepala* the spikes are sparingly branched at the base and the bracts are 8 mm long or less

3. **Sanchezia oxysepala** Mildbr. Notizbl. Bot. Gart. Berlin 9: 983. 1926

Stem quadrangular, glabrous, petioles 2 to 5 cm long, leaf blades elliptic-ovate, up to 25 cm long, 12 cm wide, acuminate, repand-dentate, glabrous; inflorescence terminal, of one to several unilateral spikes, bracts opposite, those subtending the flowers 6 to 7 mm long, the sterile one much smaller, bractlets 8 mm long, 2 mm wide, sepals linear-subulate, 2.5 to 3 cm long, 2.5 mm wide, corolla 5 cm long, the lobes 5 to 6 mm long, 4 mm wide, stamens exserted, pilose; staminodes 2.5 cm long, capitate, pilose

Type collected at mouth of Río Santiago, Department of Loreto, Peru, by G. Tessmann (no. 3874a). Photograph in the U. S. National Herbarium and in the herbarium of the New York Botanical Garden

No actual specimens have been seen by the writer

4. **Sanchezia sprucei** Lindau, Bull. Herb. Boiss. 5: 648. 1897

Stem terete, pubescent, petioles 6 to 12 mm long, pubescent, leaf blades elliptic up to 11 cm long, 4.5 cm wide, acute at apex and base, sparingly pilose, the cystoliths prominent, inflorescence terminal, of one or more interrupted spikes, bracts (one subtending the flower, the opposite one sterile) ovate, 7 to 13 mm long, 2 to 5 mm wide, acuminate, pilose; bractlets lanceolate, 1.3 cm long, 4 mm wide, calyx segments 2 to 2.2 cm long, 3.5 to 4.5 mm wide, the margin pilose and subhyaline; corolla 3.8 cm long, 9 mm wide at middle, the lobes 3 mm in diameter, stamens exserted, the filaments sparingly pilose, anthers 4 mm long, staminodes 1.5 to 1.8 cm long, glabrous; style 4.5 cm long; stigma 4 mm long, capsule 1.6 cm. long, 8-seeded

Type collected near Tarapoto, Peru, by R. Spruce (no. 4325). Type collection in the Gray Herbarium, photograph in the U. S. National Herbarium

Near *S. oxysepala*, but distinguished from that species by the smaller leaves, pubescent stems, and the shorter glabrous staminodes

5. **Sanchezia sylvestris** Leonard, sp. nov

Frutex, ramis subtetragonis glabris; foliis ellipticis vel oblongo-ellipticis basi obtusis apice abrupte breviterque acuminatis glabris, margine sinuato-

dentato; inflorescentia terminali paniculata, bracteis oppositis ovatis acutis subtiliter ciliatis, bracteolis ovatis obtusis parce puberulis ciliatis, calycis laciniis oblongis paullum maequalibus; corolla puniceа glabra, lobis ciliatis exceptis, filamentis parce pilosis, staminodiis basi tomentosis apice glabris

Shrub 1 meter high, stem quadrangular with rounded angles, glabrous; petioles 2 to 3 cm. long, glabrous, leaf blades elliptic to oblong-elliptic, up to 17 cm. long, 10 cm wide, abruptly narrowed to a slender tip, obtuse at base, shallowly sinuate-dentate, glabrous, the upper surface marked with numerous, very minute, papillate projections, the cystoliths rather numerous and prominent, closely parallel on the nerves and midrib, inflorescence a terminal panicle about 20 cm long, composed of slender unilateral spikes, bracts opposite (one subtending a flower, the other sterile), ovate, 3 to 6 mm long, 1 to 2 mm. wide, acute, minutely ciliate, bractlets ovate, 4 to 5 mm long, 3 mm wide, obtuse, sparingly puberulent and ciliolate; calyx segments oblong, slightly unequal, 9 to 10 mm long, 2 to 3 mm wide, obtuse and apiculate at apex, glabrous or inconspicuously and sparingly puberulent, furfuraceous toward tip, ciliolate, corolla 4 cm long, pink, glabrous (except the finely ciliate lobes), 3 mm broad at base, 7 to 8 mm broad at throat, the lobes 3 mm. long, 2 5 mm wide, emarginate; stamens 3 5 to 4 cm long, the filaments flat and sparingly pilose, the anthers 5 mm long, staminodes 1 5 cm. long, 0 5 mm broad at base, flat and tomentose toward base, the upper portion glabrous, very slender and narrowly spatulate at tip, style 4 to 5 cm long, glabrous; capsule 1 2 cm long, 3 mm broad, glabrous, or with a few appressed hairs near the tip

Type in the U S National Herbarium, no 1,461,741, collected in dense forest between Yurimaguas and Balsapuerto, Department of Loreto, Peru, altitude 135 to 150 meters, August 26, 1929, by E P Killip and A C Smith (no 28093) Klug's 1653, collected in the Río Putumayo forest, is also of this species

Sanchezia sylvestris is readily distinguished by its minute bracts, which are seldom more than 5 mm long In all other Peruvian species the bracts are 10 mm long or more

6 **Sanchezia rosea** Leonard, sp nov

Frutex, ramis subtetragonis glabris, foliis oblongo-ellipticis glabris, apice acuminatis basi acutis, margine leviter crenato-dentato, spica subunilaterali, bracteis ovato-lanceolatis glabris vel subtiliter ciliatis, bracteolis oblongo-ovatis glabris, calycis laciniis oblongis apice rotundatis et mucronulatis, corolla lutea glabra, lobis parce ciliatis exceptis, staminodiis basi tomentosis apice pilosis

Low shrub, stem quadrangular with rounded angles, glabrous, petioles 2 to 4 cm long, glabrous, leaf blades oblong-elliptic, up to 24 cm long, 9 cm wide, acuminate at apex, acute at base, shallowly crenate-dentate except the basal third (here entire), glabrous, the upper surface bearing minute papillate projections but these less numerous and conspicuous than in *S sylvestris*, the cystoliths 0 5 mm long, inflorescence spicate, imperfectly unilateral, bracts opposite (one subtending a sessile cluster of several flowers, the other slightly smaller, sterile, or subtending a single flower), ovate-lanceolate, 1.6 to 2 5 cm long, 6 to 11 mm. wide near base, gradually narrowed to a slender tip, glabrous or minutely ciliate, the cystoliths parallel and rather prominent; bractlets oblong-ovate to oblong, 6 to 16 mm long, 2 to 5 mm

wide, glabrous, calyx segments oblong, equal or nearly so, 1.5 to 1.8 cm. long, 2 to 4 mm wide, rounded and mucronulate at apex, conspicuously puberulent and ciliate at tip, otherwise glabrous, the cystoliths minute and parallel; corolla light red, glabrous without except for a few scattered hairs on the margin of the lobes, glabrous within except for a white tomentum about the insertion of the stamens, 4 to 5 cm. long, 3 mm. broad at base, 1 cm broad at throat, slightly constricted at mouth, the lobes 3 mm. long, 2 mm wide, rounded and emarginate at apex, stamens exserted about 5 mm., the filaments sparingly pilose, the anthers 5 mm. long; staminodes 1.8 cm. long, ending in a flat spatulate tip 0 75 mm wide, white-tomentose at base, otherwise pilose with spreading hairs 1 to 2 5 mm long; style slightly exceeding the stamens

Type in the U S National Herbarium, no 1,461,695, collected in woods along the lower Río Huallaga, Yurimaguas, Department of Loreto, Peru, altitude about 135 meters, August 25, 1929, by E P Killip and A C Smith (no 28040)

Sanchezia rosea is related to *S tigrina*, from which it differs mainly in its thinner leaf blades, longer bracts, and pilose staminodes Although it agrees with *S loranthifolia* in having pilose staminodes, it does not possess the puberulent corolla and firm dark leaf blades of that species.

7 **Sanchezia loranthifolia** Lindau, Bull Herb. Boiss. II **4**: 314 1904

Stem quadrangular, glabrous, leaf blades oblong, up to 18 cm long and 5 cm wide, acuminate at apex, narrowed at base to a short petiole, glabrous, firm and dark colored, the cystoliths conspicuous, inflorescence a terminal panicle, the flowers in clusters of 4 to 6 crowded in the axil of one of each pair of bracts, bracts ovate, obtuse, up to 1 6 cm long, 6 mm wide; bractlets up to 1 4 cm long, 3 5 mm wide, calyx segments unequal, 1 7 to 2 cm long, 3 to 4 mm wide, corolla red, 4 mm wide at base, 9 mm wide at throat, puberulent toward tip, the lobes 5 mm. long, 3 mm. wide; stamens 4 2 cm long, pilose, staminodes 1 4 to 1 7 cm long, pilose, spatulate at tip, style 5 cm long, glabrous, capsule 1 7 cm long, 2 5 mm in diameter, glabrous.

Type collected along the Cumbaso River, near San Pedro, Department of Loreto, Peru, by E. Ule (no 6820)

I have seen no material of this species, and the above description is compiled from the original

8 **Sanchezia tigrina** Leonard, sp. nov

Frutex, ramis tetragonis glabris, nodis parce pubescentibus exceptis; foliis oblongo-ellipticis basi acutis, apice acuminatis glabris, marginibus integerrimis vel undulatis, inflorescentia terminali paniculata, spicis pluribus unilateralibus, bracteis oblongis vel oblongo-ovatis puberulis, margine subscarioso; bracteolis oblongis, corolla glabra, lobis parce ciliatis exceptis; staminodiis basi tomentosis apice glabris

Shrub; stem quadrangular, glabrous or sparingly pubescent at nodes; petioles up to 2 5 cm long, channeled, sparingly puberulent above, glabrous beneath; leaf blades oblong-elliptic, up to 25 cm long, 8 cm. wide, narrowed and acuminate at apex, narrowed at base, firm, drying olive-brown, entire and undulate, both surfaces glabrous, the upper marked by numerous minute papillae, the cystoliths 0 5 to 0 75 mm. long, inflorescence a terminal panicle

consisting of several unilateral spikes, the lowermost node 1 to 3 cm long, the others successively shorter, pubescent, the flowers in clusters of 3 or 4, or solitary, sessile in the axil of one of each pair of bracts, the opposite bract sterile; bracts oblong to oblong-ovate, up to 1.7 cm long, 7 mm wide, acute at apex, puberulent, the margin subscarious, ciliolate, bractlets oblong, up to 15 mm long, 5 mm. wide, obtuse; calyx segments oblong, 1 5 to 1 7 cm long, 3 to 5 mm. broad, obtuse and sparingly pubescent at apex, the margin scarious; corolla glabrous except for a few scattered hairs at the margin of the lobes, 4 5 cm long, 3 mm. broad at base, slightly contracted, 1 2 cm broad at mouth, the lower portion of the throat streaked with brown (dry flower), the lobes 5 mm long, 4 mm wide, shallowly emarginate, conspicuously reticulate; filaments white-tomentose at base, sparingly pilose above; anthers 4 mm. long; staminodes 1 5 to 1 8 cm. long, white-tomentose below, glabrous above, narrowly capitate; style 5 to 6 cm. long, glabrous, stigma linear, one lobe 2 mm long, the other vestigial.

Type in the U S. National Herbarium, no 1,444,803, collected at Iquitos, Department of Loreto, Peru, altitude 120 meters, October, 1929, by Llewelyn Williams (no 3622).

This species is closely related to *S. loranthifolia*, but is distinct in its glabrous corolla, puberulent bracts, and smaller calyx The specific name was chosen because of the peculiar markings on the lower part of the corolla throat, a character found in only a few species of *Sanchezia*

The color of the flowers can not be determined with any degree of certainty from the type. Judging from the closely related species *S sylvestris*, *S rosea*, and *S. loranthifolia*, it may be inferred that they are either red or pink.

9. **Sanchezia conferta** Leonard, sp nov.

Frutex, ramis tetragonis glabris, nodis pubescentibus exceptis; foliis ovatis glabris, basi rotundatis vel obtusis, apice acuminatis, margine sinuato-dentato; spica densa, floribus confertis, bracteis ovatis acutis vel obtusis, bracteolis oblongis obtusis pubescentibus, calycis laciniis oblongo-lanceolatis, paullum inaequalibus, corolla glabra, lobis pilosis exceptis, staminodiis angustis glabris vel parce pubescentibus

Stem quadrangular, glabrous or pubescent at the nodes, petioles up to 2 cm long, channeled, glabrous; leaf blades ovate, up to 14 cm long and 6 cm. wide, acuminate at apex, rounded or obtuse at base, shallowly sinuate-dentate, glabrous, the cystoliths about 0 5 mm long, inconspicuous, surrounded by minute papillate projections, inflorescence terminal, the flowers numerous and crowded in the axils of the bracts, the internodes short and concealed by the flowers, pubescent, bracts ovate, up to 1 5 cm. long, acute or subobtuse at apex, bractlets oblong, subobtuse, pubescent, much smaller than the bracts, calyx segments subequal, oblanceolate, 2 to 2 3 cm long, 2 to 2 5 mm wide at base, 2 5 to 4 mm wide above middle, acute at apex, thin, pubescent without with ascending hairs up to 0 75 mm long, glabrous within, corolla 4 5 cm. long, 2 5 mm broad at base, 8 mm broad at throat, glabrous except for the lobes, these 4 mm long, 3 5 mm wide, emarginate, rather conspicuously pilose with hairs up to 0 5 mm long, filaments white-tomentose at base, sparingly pilose above, staminodes 10 mm long, linear, glabrous, or bearing a few minute hairs at the margin, style glabrous

Type in the U S National Herbarium, no 1,359,680, collected in dense

forest on Pichis trail to Yapas, Department of Junín, Peru, altitude 1,350 to 1,600 meters, June 29, 1929, by E. P. Killip and A. C. Smith (no. 25479).

Although evidently related to the small-bracted group of *Sanchezia* (*S. sylvestris*, *S. rosea*, *S. loranthifolia*, and *S. tigrina*), this species is strongly differentiated by its compact inflorescence, larger calyx, and shorter staminodes.

10. **Sanchezia capitata** (Nees) Lindau, Bull. Herb. Boiss. II. 4: 315. 1904.
Ancylogyne capitata Nees in DC. Prodr. 11: 222. 1847.

Shrub up to 2 meters high; stem subquadrangular, glabrous; petioles 3 to 4 cm. long, glabrous; leaf blades ovate to obovate, up to 28 cm. long, 9 cm. wide, acuminate, gradually narrowed from about the middle to base, undulate-crenate, entire at base, glabrous; inflorescence terminal, the flowers crowded in several compact heads up to 4 cm. broad on stout peduncles about 3 cm. long; bracts red, oblong, up to 5 mm. long, acute; calyx segments (mature) linear-oblong, 3.3 to 3.5 cm. long, 4 to 5 mm. wide, obtuse or rounded at apex, glabrous; corolla 2.5 cm. long, red; capsule 1 to 1.2 cm. long, 3 to 4 mm. broad; seeds lenticular, 4.5 mm. broad, about 1 mm. thick, brown.

Type collected at Pangoa, Peru, by A. Mathews (no. 1230).

Peruvian specimen examined:—

JUNÍN: Pichis Trail, between San Nicolas and Azupizú, 650 to 900 meters, *Killip & Smith* 26092.

This specimen agrees very well with Nees' brief description of *Ancylogyne capitata*, at least in respect to the leaves and inflorescence. The Killip and Smith plant is well beyond the flowering stage, and no corollas are present.

11. **Sanchezia ovata** R. & P. Fl. Peruv. Chil. 1: 7. *pl. 8, fig. c.* 1798.
Sanchezia glabra Pers. Syn. Pl. 1: 24. 1805.

Stem quadrangular, glabrous; leaf blades ovate, acuminate, entire, pubescent; inflorescence a terminal spike, the flowers sessile and crowded in the axils of the purple, ovate, acute, concave bracts; bractlets oblong, emarginate, purplish; calyx segments oblong, rounded; corolla yellow, glabrous; filaments hirsute except at base; staminodes about 4 mm. long.

Reported from Cuchero, Pozuzo, and Pillao, Peru, by Ruiz and Pavon.

As no material is available for my examination, the description is compiled from the original.

12. **Sanchezia cyathibracteata** Mildbr. Notizbl. Bot. Gart. Berlin 9: 267. 1925.

Stem stout, glabrous; petioles 4 to 6 cm. long; leaf blades oval, up to 30 cm. long, 16 cm. wide, obtuse at apex, subcuneate at base, coarsely crenate-undulate, the nerves 15 to 17 on each side of midrib; inflorescence a spike up to 20 cm. long, the internodes 3 to 4 cm. long; bracts ovate, 4 to 5 cm. long, connate to middle or beyond; flowers numerous, sessile; calyx segments unequal, 1.3 to 1.6 cm. long, 3 to 4 mm. wide, rounded at apex; corolla glabrous, yellow, 5 cm. long, the throat 8 mm. broad, the lobes 5 mm. long, 3 mm. broad; filaments 4 cm. long; anthers 6 mm. long; staminodes 5 mm. long.

Type collected at the mouth of the Capanahua River, eastern Peru, by G. Tessmann (no. 3134).

The relationship between this species, the type of which I have not seen, and *S pennellii* is extremely close, the main differences lying in the number of lateral nerves of the leaves and in the size of the corolla lobes Further material may show that the two are conspecific

13. **Sanchezia pennellii** Leonard, Journ Washington Acad Sci. 16: 488 1926

Stem obscurely quadrangular, glabrous, petioles up to 4 cm long, leaf blades elliptic to elliptic-obovate, up to 30 cm long, 13 cm wide, abruptly narrowed to a blunt tip, narrowed at base, shallowly crenate, glabrous, the lateral nerves 9 to 12 to a side, inflorescence a terminal spike, bracts ovate, up to 5 cm long and 3 5 cm wide, connate at base, acute to obtuse at apex, red; sepals ligulate-obovate, 1 to 1 5 cm long, 2 to 5 mm broad, corolla yellow, 4 to 5 cm long, 6 to 7 mm broad at throat, the lobes 3 mm long, rounded and emarginate at apex, filaments pilose, staminodes 4 to 5 mm long, style glabrous

Type collected at Vuelta de Acuña, Magdalena River, Department of Antioquía, Colombia, by F W Pennell (no 3798)

RANGE Panama, Colombia, Peru.

Peruvian specimens examined —

LORETO Dense forests at Yurimaguas, Lower Río Huallaga, about 135 meters, *Killip & Smith* 27993 Dense forests, Santa Rosa, lower Río Huallaga below Yurimaguas, 135 meters, *Killip & Smith* 28829

The inflorescence of both Peruvian specimens is immature and the corollas are not fully developed; the leaves and bracts, however, agree well with those of specimens from Panama and Colombia

14 **Sanchezia oblonga** R & P Fl Peruv Chil 1: 7 *pl 8, fig b* 1798.
Sanchezia hirsuta Pers Syn Pl 1: 24 1805

Stem glabrous, petioles winged, connate, leaf blades oblong-lanceolate, acuminate, glabrous, inflorescence a terminal spike with a few short lateral branches, bracts ovate, red, pubescent, bractlets linear, hirsute, red, calyx segments rounded at apex, yellow, corolla yellow, filaments hirsute, staminodes 4 to 5 mm long

Reported from Cuchera, Pozuzo, and Pillao, Peru, by Ruiz and Pavon

15 **Sanchezia macbridei** Leonard, Journ Washington Acad Sci 16: 487 1926

Stem glabrous, petioles winged, leaf blades up to 30 cm long, 12 cm wide, acuminate at tip, narrowed to a somewhat clasping base, undulate-dentate, glabrous, inflorescence spicate, or occasionally with a few lateral branches; bracts ovate, up to 5 cm long, 3 cm wide, red, glabrous, the lower long-acuminate, the upper obtuse at apex, bractlets oblong, up to 2 5 cm long, 1 cm wide, obtuse at tip, sepals 1 5 to 1 8 cm long, 2 to 4 mm wide, rounded at apex, corolla yellow, the tube up to 5 cm long, finely appressed-pubescent, the lobes 4 to 5 mm long, 2 5 mm wide, filaments 4 5 cm long, pubescent below with white hairs 0 5 mm long, sparingly pilose above with hairs up to 1 5 mm long, staminodes 1 5 to 1 8 cm long, white-pubescent at base, glabrous at tip, style 6 cm long, pubescent toward base

Type collected at the mouth of the Chinchao River, Pampayacu, Peru by J F Macbride (no 5056)

Peruvian specimens examined.—

LORETO: Soledad, Río Itaya, 110 meters, in dense forests, *Killip & Smith* 29549.

HUÁNUCO: Pampayacu, *Macbride* 5056 (type).

JUNÍN: La Merced, 700 meters, thickets, *Killip & Smith* 23411.

AYACUCHO: Río Apurimac Valley, near Kimpitiriki, 400 meters, edge of forest along beach, *Killip & Smith* 22954. Densely forested valley at Ccarrapa, between Huanta and Río Apurimac, 1,500 meters, *Killip & Smith* 23205

This species is readily recognized by its large bracts and its conspicuous, bright yellow, pubescent flowers.

16 **Sanchezia peruviana** (Nees) Rusby, Mem. Torrey Club 6: 103. 1896.
Ancylogyne peruviana Nees in DC Prodr 11: 222. 1847.

Stem quadrangular, glabrous, leaf blades oblong-elliptic or obovate, up to 35 cm long, 15 cm. wide, acuminate at apex, narrowed from below middle to a winged petiole, sinuate-dentate, glabrous; inflorescence a terminal spike up to 20 cm long, the lowermost internode up to 8 cm long, the others successively shorter, the upper ones hidden by the flower clusters; bracts opposite, ovate, up to 3 5 cm. long, 4 cm. wide, obtuse, bright red, glabrous, bractlets oblong; calyx segments unequal, 2 2, 2 5, and 3 cm long, 2 to 7 mm. wide, rounded at apex, corolla 4 cm long, red, glabrous, or the lobes sparingly ciliate, filaments tomentose at base, pilose above, the hairs spreading, up to 2 mm long; staminodes 2 to 3 mm long, tomentose at base, glabrous above

Type collected at Sesuija, Peru, by Mathews (no 1221)

RANGE Peru and Bolivia

Peruvian specimens examined —

SAN MARTÍN San Roque, 1,350 to 1,500 meters, *Williams* 6933.

JUNÍN Wooded valley, La Merced, 1,200 meters, *Schunke* 292; *Killip & Smith* 24080

Sanchezia peruviana has inflorescence and flower parts similar to those of *S munita* (Nees) Planch , a native of Brazil, but is distinguished by the character of the leaves In *S munita* the petioles are wingless, and the leaf blades, usually under 20 cm in length, are entire On the other hand, the petioles of *S peruviana* are broadly winged and the blades are sinuate-dentate

17 **Sanchezia flava** Leonard, sp nov.

Frutex, ramis tetragonis glabris, foliis oblongo-ellipticis vel oblongo-obovatis glabris, apice acuminatis, basi acutis, margine sinuato-dentato, petiolis alatis; spica simplici vel parce divisa, bracteis ovatis, infimis acutis rubris, summis obtusis flavis, bracteolis oblongis, calycis laciniis oblongo-ovatis rotundatis inaequalibus, corolla lutea glabra, lobis parce ciliatis exceptis, staminodiis gracilibus pilosis

Shrub 1 to 2 meters high, stem quadrangular, glabrous, leaves narrowed into short, winged petioles; leaf blades oblong-elliptic to oblong-obovate, up to 30 cm long, 13 cm wide, acuminate at apex, acute at base, rather shallowly sinuate-dentate, glabrous; inflorescence spicate, simple or bearing one or more branches at the basal node, the upper nodes hidden by the bracts; bracts ovate, up to 4 cm long, 3 cm wide, the lower acute and bright red, the upper obtuse and yellow, bractlets oblong; calyx segments unequal, oblong-ovate, 2 to 2 5 cm long, 2 to 7 mm wide, rounded at apex; corolla bright yellow, glabrous, or with a few minute hairs near the tip of the lobes,

about 5 cm. long, 7 mm. broad, the lobes suborbicular, about 3.5 mm. in diameter; filaments finely pubescent below, pilose above with hairs 2 mm. long; staminodes 2 cm. long, slender and pilose above; ovary glabrous; style 5 cm. long, rather densely pilose below with hairs 0.5 mm long, glabrous above.

Type in the U. S. National Herbarium, no 1,358,997, collected in dense forest of the Schunke Hacienda, above San Ramón, Department of Junín, Peru, altitude 1,400 to 1,700 meters, June 8, 1929 by E P Killip and A C Smith (no 24640).

This differs from *S peruviana* in its yellow flowers and long slender pilose staminodes.

18. **Sanchezia rubriflora** Leonard, sp nov

Frutex, ramis tetragonis glabris; foliis oblongo-ellipticis vel leviter obovatis glabris, apice acuminatis, basi acutis, margine integerrimo vel leviter crenato; spica terminali; bracteis infimis lanceolatis acuminatis, summis ovatis obtusis rubris; bracteolis oblongis obtusis; calycis laciniis paullum inaequalibus angustis oblongo-ovatis apice rotundatis glabris, corolla rubra glabra vel lobis apice parce pilosis, staminodiis angustis, basi tomentosis apice glabris

Shrub 2 or 3 meters high; stem quadrangular, glabrous, petioles up to 4 cm. long, glabrous, leaf blades oblong-elliptic or slightly obovate, up to 25 cm long, 12 cm wide, acuminate at apex, acute or acutish at base, entire or shallowly crenate, glabrous (nerves and midrib bright yellow in *Macbride* 4665); inflorescence a terminal spike, the lowermost internode up to 9 cm. long, the others successively shorter, those near the tip hidden by the bracts; lowest pair of bracts lanceolate, 2 cm long, 2 cm wide near the base, gradually narrowed to a slender tip, the upper bracts ovate, smaller, obtuse, all red and glabrous, bractlets oblong, obtuse, flowers several in each axil, calyx segments subequal, narrowly oblong-ovate, 1 8 to 2 cm long, 3 to 5 mm. wide, rounded at tip, glabrous, corolla red, glabrous or with a few hairs near tip of lobes, 4 to 5 cm long, 2 mm in diameter at base, 7 mm wide above base, the lobes 3 mm long, 2 5 mm wide, emarginate; stamens 4 to 5 cm long, the filaments white-tomentose below, sparingly pilose above with hairs 1 mm. long; staminodes linear, about 10 mm long, white-tomentose below, glabrous above, ovary and style glabrous, or the style bearing a few long hairs near base

Type in the U S. National Herbarium, no 1,460,617, collected in dense forest at Cahuapanas, Río Pichis, Department of Junín, Peru, altitude about 340 meters, July 20, 1929, by E. P Killip and A C Smith (no 26768)

Additional Peruvian specimens examined —

LORETO. La Victoria, Amazon River, *Williams* 2880

HUÁNUCO· Pozuzo, *Macbride* 4665

This closely resembles *S. munita*, of western Brazil, but that species has staminodes about 2 mm long (not 10 mm long or more, as in *S. rubriflora*) Macbride's no 4665 was erroneously cited in my previous paper as *S. peruviana.*

19 **Sanchezia pulchra** Leonard, sp. nov

Frutex, ramis tetragonis glabris; foliis obovatis glabris, basi cuneatis, apice breviter acuminatis, margine crasse crenato-dentato, spica terminali, bracteis infimis lanceolatis glabris, reliquiis ovatis glabris rubris; bracteolis oblongis obtusis; calycis laciniis inaequalibus spathulatis, corolla luteo-

rubra glabra, lobis apice pilosis exceptis; staminodiis basi tomentosis, apice glabris.

Suffrutescent, 1 meter high; stem quadrangular, glabrous; petioles up to 6 cm long, glabrous, leaf blades obovate, up to 30 cm. long, 16 cm. wide, rounded or abruptly narrowed to a short acumen, cuneate at base, coarsely crenate-dentate, glabrous, inflorescence a terminal spike, the flowers clustered in the axil of the bracts, the lowermost internode up to 5 cm. long, the others partially hidden by bracts and flowers; lowermost bracts lanceolate, up to 7 cm long, 2 5 cm wide near base and gradually narrowed to tip, the others ovate, acute, all dark red and glabrous, bractlets oblong, obtuse at apex, calyx segments unequal, spatulate, 1 4 cm long, 3 to 4 mm wide toward the rounded tip, gradually narrowed to 2 mm at base, glabrous, the margin subscarious, corolla orange-red, glabrous except for a tuft of hairs at tip of lobes and a white tomentum at insertion of stamens, 4 to 4 5 cm long, the tube 2 mm broad, the throat 6 to 8 mm broad, the lobes about 3 mm long and broad, emarginate, reticulate-veined, filaments white-tomentose at base, pilose above with hairs up to 1 mm long, staminodes 3 to 4 mm. long, white-tomentose except for the glabrous tip; ovary and style glabrous

Type in the U S National Herbarium, no 1,461,526, collected in dense forest at Puerto Arturo, lower Río Huallaga below Yurimaguas, Peru, August 24, 1929, by E P Killip and A. C Smith (no 27842).

Additional Peruvian specimens examined —

LORETO Forest, Mishuayacu, near Iquitos, 100 meters, *Klug* 667 Lower Río Huallaga, 155 to 210 meters, *Williams* 5143.

JUNÍN Dense forest, Puerto Bermudez, 375 meters, *Killip & Smith* 26447

This is distinguished from *S rubriflora* and *S pulchra* by its large, obovate, coarsely crenate-dentate leaves It is further differentiated from *S rubriflora* by its short staminodes.

Killip & Smith's 26447, from Puerto Bermudez, is doubtfully referred to *S pulchra* In this specimen the inflorescence is very immature, and the upper pair of leaves have broadly winged, clasping petioles, although the second pair are typically slender-petioled

20 **Sanchezia stenantha** Leonard, Journ Washington Acad Sci **16:** 489 1926

Stem quadrangular; petioles slender, 4 to 6 cm long, leaf blades ovate to oblong-ovate, up to 25 cm long, 12 cm wide, acuminate at apex, rounded or obtuse at base, entire or undulate, glabrous; inflorescence a terminal spike (occasionally capitate), the lowermost internode up to 7 cm long, the others much shorter and hidden by the bracts, bracts ovate, concave, up to 4 cm long, 2 5 cm wide, obtuse or acutish at apex, bright red, bractlets oblong-obovate, sepals equal, obovate, narrowed to a slender base, rounded at apex, about 1 5 cm long, 4 to 8 mm wide, corolla bright yellow, glabrous (lobes sparingly ciliate), 4 to 5 cm long, 6 to 7 mm broad, filaments white-pubescent at base, sparingly pilose above with hairs about 1 mm. long, staminodes 1 3 to 1 4 cm. long, white-pubescent below, glabrous above, style glabrous

Type collected at Pozuzo, by J F Macbride (no 4634)

Peruvian specimens examined —

HUÁNUCO Pozuzo, 650 meters, *Macbride* 4634 (type)

JUNÍN: Dense forests, Yapas, Pichis Trail, 1,350 to 1,600 meters, *Killip & Smith* 25472. Thickets, Meriatiriani, Pichis Trail, 500 meters, *Killip & Smith* 26207. Dense forest, Río Paucartambo Valley, near Perene Bridge, 700 meters, *Killip & Smith* 25287

A well-marked species, easily recognized by the ovate, nearly entire leaf blades with rounded bases, and by the large compact spike of bright yellow flowers.

21. **Sanchezia killipii** Leonard, sp nov

Frutex, ramis tetragonis glabris, foliis oblongo-ellipticis glabris utrinque acutis, margine undulato; spica terminali, bracteis acutis glabris, bracteolis oblongis obtusis, calycis laciniis oblongis inaequalibus obtusis glabris, corolla lutea glabra; staminodiis basi tomentosis, apice pilosis

Shrub about 1 meter high; stem quadrangular, glabrous; petioles up to 1 5 cm long, glabrous, leaf blades oblong-elliptic, up to 18 cm long, 7 cm wide, narrowed at both ends, glabrous, entire or shallowly undulate, inflorescence a terminal spike, the flowers clustered in the axils of the bracts (sometimes short secondary spikes present in the axils of the lower bracts), the lowermost internode 3 5 cm long, the others successively shorter, about equaling the flower clusters, bracts (lowermost pair not seen) ovate, up to 2 2 cm long, 1 8 cm wide, acute, glabrous, bractlets oblong, obtuse, calyx segments oblong, subequal, 1 8 to 2 cm long, 4 to 6 mm wide, obtuse at apex, narrowed at base, glabrous, corolla yellow, glabrous except for a white tomentum at insertion of stamens, 4 cm long, 3 mm wide at base, 9 mm wide at middle, 6 mm wide at mouth, the lobes 3 mm long, 3 5 mm wide, emarginate, filaments white-tomentose at base, pilose above with hairs up to 2 mm long, staminodes about 15 mm long, white-tomentose below, pilose above, the hairs most numerous and longest just below the slightly enlarged curved tip, ovary and style glabrous

Type in the U S National Herbarium, no 1,462,404, collected in dense forests of Santa Rosa, lower Río Huallaga below Yurimaguas, Peru, altitude about 135 meters, Sept 4, 1929, by E P Killip and A C Smith (no 28967)

In the character of the staminodes this species agrees with *S flava*, but can be distinguished by its well-defined, wingless petioles

ENTOMOLOGY.—*New species of Sphingidae and Saturniidae in the U. S. National Museum.*[1] W. SCHAUS, Bureau of Entomology. (Communicated by HAROLD MORRISON)

The new species described herein have been received within recent times and are a valuable addition to the national collections. They include 15 new species, one subspecies, two races, and one aberration.

SPHINGIDAE

Protoparce camposi, new species

Male —Palpi iron gray above, white underneath Head, collar, and tegulae iron gray, a white spot at base of antenna and at side of neck Thorax dark olive gray Abdomen above black, thickly mottled with white and

[1] Received January 13, 1932

pinkish buff scales, leaving a dorsal interrupted black line and subdorsal white spots, three large lateral chrome spots on basal segments, broadly edged sublaterally with black, sublateral segmental white lines connected by a wavy white line; venter whitish with transverse gray bands. Fore wing fuscous black, a short white basal line from subcostal to below cell, a patch of white hairs at base of inner margin, an antemedial white lunular line, outbent on costa, outangled in cell and inbent to inner margin preceded by some fine white lines to submedian fold and diverging on costa; medial area with some grayish and faint cinnamon irrorations; a wavy jet black line follows the antemedial, and a dentate similar line precedes the postmedial, and consists partly of cuneiform spots; a small white spot on discocellular; postmedial line narrow, white, lunular dentate edged with jet black almost vertical from costa, inbent below vein 4, followed by diffuse grayish and cinnamon scaling to the black lunular dentate subterminal line; a wavy black line, from the subterminal at vein 6 to apex, mottled above with white and gray and preceded by a fuscous black space expanding at costa; a similar fuscous black spot, from vein 2 to inner margin at tornus, edged outwardly with white, a broken marginal black line partly defined by white scaling; some grayish shading on termen, cilia black with white spots on interspaces. Hind wing fuscous black, an antemedial white patch from costa to below cell, a postmedial series of small white spots forming a distinct line below middle, upcurved at inner margin, with two other curved short white lines above it on inner margin, all separated by black lines, the postmedial spots edged above by a dentate black line and some very small white spots, cilia white at anal angle, otherwise black with white spots. Fore wing below with fuscous streaks in and below cell; costa and outer half thickly irrorated with white scales, a white line on discocellular, postmedial line black edged with white, more distinctly on inner side, some white scaling at apex. Hind wing below: Base white irrorated with deep mouse gray; a fuscous dentate medial line, postmedial line broader, black, deeply dentate, edged with white, on basal side the white edged by a fine dark line, termen thickly irrorated with white.

Expanse, 118 mm

Habitat—Ecuador

Type—Cat No 34401, U S N M

Protoparce florestan ishkal, new subspecies

Male —Palpi white, tipped with pale smoke gray Head, thorax, and fore wing pale smoke gray, a fine black line from shoulders curved at front of collar, also extending below shoulder as a thick black line along outer edge of tegulae. Abdomen above mottled with dark scales, segmental black lines; subdorsal black spots on basal segment, a lateral black line expanding at segmental lines, except on three terminal segments; a sublateral fine fuscous line; body below white with ventral fuscous spots on terminal segments. Fore wing irrorated with fine black scales, in places absent, forming whitish edging to the postmedial lines, also to the antemedial line proximally; a black basal and a subbasal spot on costa, and an intermediate spot near base of cell, antemedial line lunular, inbent below cell; medial line double, lunular, black, outcurved, below cell fainter inbent, parallel with antemedial, incurved to near base on inner margin; a white point on discocellular, followed by an interrupted black line crenulate below vein 4 to inner margin; postmedial line outcurved, triple below vein 5, finely crenulate and incurved below vein 4,

partly edged with white towards inner margin; subterminal line outbent from costa to vein 6, where it is connected with the apex by an irregular black line, below vein 6 the line crenulate on interspaces and disconnected, small marginal black lunules at veins 3 and 4, cilia white with black spots at veins. Hind wing. Costa whitish to postmedial line; basal third benzo brown; thick fuscous black streaks from base below cell and before inner margin to medial line; inner margin cinnamon drab; medial line broad, fuscous black, excurved and downcurved at inner margin followed below vein 5 by whitish and crossed by a downcurved fine black line at inner margin; postmedial line broad from costa, fuscous black, suffusing with the fuscous termen to vein 5, diminishing in width towards anal angle, termen from below vein 5 broadly pale smoke gray; cilia as on fore wing. Wings below with the termen broadly dark cinnamon drab with fine whitish irrorations on outer half Fore wing· Costa grayish; inner margin from cell and to postmedial line whitish; postmedial outcurved at costa and inbent, parallel with termen, benzo brown, edged on either side with whitish Hind wing white with dark irrorations on costa, in cell, and beyond medial line, the latter thick, benzo brown, irregular, and somewhat dentate, postmedial line fine, dentate, becoming indistinct towards inner margin Female the same as male, but the termen of hind wing less extensively gray, but with a broad white patch on inner margin between the two lines

Expanse, male 100 mm , female 112 mm.

Habitat —Tehuacan, Mexico

Type —Cat No 34476, U S N. M

An examination of the genitalia shows this to be a good subspecies of *P florestan* Cr.

The longitudinal black lines on fore wing of *P florestan* are entirely absent

Protoparce florestan cabnal, new race

Male —The fore wing with a large medial space mottled cinnamon drab and rufous, irregularly triangular with its apex at vein 2, and with short black streaks on veins 3 and 4 near cell; the subterminal black line is fine wavily lunular, outwardly with drab scaling and a dentate whitish line, below vein 2 the drab scaling becoming cinnamon drab, cilia white interrupted by black lines.

Expanse, Male 92 mm , female 140 mm.

Habitat —Jalapa, Mexico; Texas

Type.—Cat. No. 34477, U. S N. M

This race seems confined to the temperate district of Eastern Mexico, extending into Brownsville, Texas

Ceratomia igualana, new species

Male.—Palpi fuscous black, heavily fringed with white on first and second joints Head, thorax, and abdomen above dark drab gray; a velvety black line, medially angled on front of collar, outbent on collar, and continued along outer edge of tegulae and a fine line on dorsal edge of tegulae, metathorax somewhat paler, abdomen dorsally with a fine interrupted black line, sub-dorsal whitish points at the lunular black lateral line, abdomen below whitish; thorax below with a lateral broad black line Fore wing dark drab gray; a white point at base, a fine darker curved subbasal line and a similar double antemedial line, a more distinct black line, closely accompanied by a faint line, outbent from costa before middle to median, then angled and inbent

to inner margin at antemedial line; postmedial line black, outcurved, well marked, below vein 4 inbent to middle of inner margin, and closely followed by a double, fainter, lunular line; subterminal line fine, black, outcurved from costa to vein 4, then slightly incurved; a black streak above veins 2 and 3 from cell to subterminal line, a wavy black streak from subterminal above vein 6 to apex; two shorter streaks from subterminal at veins 3 and 4 with hooks at termen; a white dark-edged point at end of cell. Hind wing fuscous with paler shading on costa and postmedially; short black and white streaks at anal angle. Fore wing below brownish drab; a pale line at discocellular, traces of a postmedial double dark line. Hind wing below somewhat paler than fore wing, the inner margin white from base to near termen; postmedial line faint. Cilia of both wings white with fuscous spots at veins.

Expanse, 57 mm.

Habitat.—Iguala, Mexico.

Type.—Cat. No. 34471, U. S. N. M.

Nannoparce balsa, new species

Female.—Palpi white, mottled with some fawn-color hairs and with a black streak above. Head and collar mouse gray; a black dorsal line on vertex, expanding on collar. Thorax medially pallid mouse gray; tegulae mouse gray, dorsally edged by a broad black line not reaching tips, outwardly edged with white. Abdomen above mouse gray with a dorsal black line and a subdorsal irregular line; body below white with black tufts at base of fore wing. Fore wing pale mouse gray with slightly darker suffusions, an irregular subbasal fine dark line and a fuscous spot at base of inner margin, a double antemedial fuscous line forming an annulus in cell, very indistinct from below cell, a double medial line from costa, also forming an annulus in cell; postmedial line faint, double, minutely dentate, slightly outbent to vein 4, then incurved, preceded by a darker quadrate spot from veins 5 to 7, crossed by short fuscous streaks, subterminal line outcurved and incurved below vein 4, suffusing with the postmedial, a black line from postmedial above vein 6 to apex; black streaks above veins 3 and 4 from cell to postmedial line; short black streaks on veins at termen crossing the white cilia. Hind wing fuscous gray, the inner margin white, a medial whitish gray shade, terminal shade with darker streaks on interspaces. Fore wing below light drab with faint traces of a postmedial darker line. Hind wing below with the inner margin more broadly white.

Expanse, 70 mm.

Habitat.—Balsas, Mexico.

Type.—Cat. No. 34472, U. S. N. M.

Hyloicus merops monjena, new race

Male.—Palpi grayish drab, fringed with paler white-tipped hairs. Head and thorax grayish drab. Collar and dorsal half of tegulae benzo brown, finely edged with black, the outer half of tegulae white, mottled with cinnamon drab scales. Abdomen as in *H. merops*. Fore wing thickly mottled white, benzo brown, and light cinnamon drab, a short black line at base of costa and below cell, the latter with some black hairs below it, a broad whitish space below cell to medial line and a narrower buffish streak from cell to postmedial, antemedial line double on costa, the outer part close and parallel

with medial line, deeply outcurved, mangled on pale space where it is cinnamon buff; medial line fine, double, fuscous, deeply outcurved with black points on it at costa and below cell, from vein 2 inbent to inner margin near base; a small whitish spot edged with black and containing a black point on discocellular, no second spot above it, postmedial line very faint, double on costa, with some whitish scales below costa, then deeply excurved, dentate, partly edged proximally with some whitish spots, a very fine black line from it at vein 6 to vein 7 near termen where it is broken and above vein 7 extends to apex, the postmedial is followed by a drab shade to subterminal, this latter outbent on costa, inwardly shaded with white, evanescent from vein 7 to near termen at vein 6, then wavy, black, inbent to vein 2 and bent downward to inner margin, followed by whitish gray scaling, a fine terminal black line, preceded by small black spots, on postmedial area vein 2 is white with black spots, cilia alternately white and drab Hind wing above as in *H merops*, the cilia white, without spots Fore wing below rather grayer, with an outcurved fuscous post-medial macular line with faint traces of a line beyond cell Hind wing below with costal half to postmedial light buff, thickly irrorated with drab; some black streaks below cell near base on a large white space to inner margin and postmedial line, this latter black, dentate from costa to vein 3, then broad and downcurved, followed throughout by a broad white space, termen grayish irrorated with drab, large fuscous quadrate blotches on interspaces

Expanse —112 mm

Habitat.—El Monje, Loja, Ecuador

Type —Cat No 34404, U S N M

Hyloicus chisoya, new species

Female —Head and thorax purplish gray, slightly mottled with paler hairs; fine oblique black lines from vertex across collar, continuing on tegulae, tegulae dorsally edged with a black line Abdomen dorsally purplish gray, with a fine black dorsal line, a subdorsal black spot at base, lateral pale purplish gray spots on two following segments, then white spots on next three segments, all broadly edged with black, abdomen below light purplish gray, mottled with white between segments; a black ventral line Fore wing purplish gray with oblique paler suffusions, a black spot at base of inner margin, a double antemedial fuscous line outcurved below cell and inbent to the black spot on inner margin, with pale suffusions above and below it, a fine black line in cell above median, and a short line above it in end of cell, heavier black streaks from cell above and below vein 3, a longer black streak above vein 5 crossing the postmedial, a postmedial fuscous shade faintly double, outcurved beyond cell and dentate, below vein 3 sinuous to middle of inner margin and outwardly edged with light purplish gray, from postmedial a fine black streak above vein 6 upturned and more heavily marked at vein 7, then oblique to apex, from vein 6 to vein 2 a slightly sinuous black line outwardly edged with white which gradually expands, a fine terminal black line, cilia fuscous with small pale spots Hind wing fuscous; base pallid purplish gray and a similar broad postmedial shade downcurved above anal angle, its anterior half suffused with cinnamon drab, cilia white, spotted with black except at anal angle and on inner margin Fore wing below hair brown; a postmedial inbent fuscous fascia with diffuse edging followed by a fainter outcurved dark shade, a fine black streak from vein 6 to apex Hind wing below

Base broadly purplish gray; a broad diffuse fuscous fascia followed by a broad pale purplish gray space; termen deep purplish gray, its proximal edge with black suffusions

Expanse.—85 mm

Habitat.—Mexico, without precise locality.

Type —Cat. No. 44470, U S. N. M.

Somewhat like Druce's figure of *H. perelegans* (*nec* Edwards) which was named by Rothschild and Jordan *H. mexicanus;* they figured a male which is again a very different species.

Hyloicus balsae, new species

Male.—Palpi white, irrorated laterally with fuscous, above thickly mottled with black, at third joint with wood brown. Head, collar, and thorax thickly mottled buffy brown and gray, the latter shade predominating on thorax dorsally, tegulae fuscous; two black lines diverging from vertex to tegulae, the latter edged with distinct black lines Abdomen dorsally hair brown with a fine dorsal black line, and fine black segmental lines; laterally the segments black with white segmental lines; abdomen below whitish Fore wing drab, suffused with gray, the lines black; a subbasal line; antemedial line double, fine, macular on costa and deeply outcurved, interrupted by veins, inbent below cell, the inner line forming a fine black line to base below median, there broadly edged below by a whitish shade, the outer antemedial cinnamon below cell where crossing the white shade, then obsolete; a double medial line, outangled in cell, slightly incurved below cell, and outcurved at median and inbent to base of inner margin forming two fine and distinct black lines; a fine black line from antemedial through cell, passing between the two white black-edged spots on discocellular to the postmedial line; black lines below veins 4 and 3 from cell to subterminal line; postmedial line wavy, outcurved, followed by another double line filled in with grayish white scaling, and cut by a grayish black-edged streak on vein 6 to termen above which is a black streak to termen close to apex, subterminal line well outcurved, sinuous, hardly traceable below vein 4, an inbent line from termen at vein 5 to vein 3; a fine terminal line, cilia white, mottled with black at veins Hind wing black, some white at base, an antemedial white shade, expanding on inner margin; a thick white postmedial line, upcurved below vein 4 and downcurved to inner margin at anal angle, cilia as on fore wing Fore wing below deep gray suffused with hair brown, a white discal point and faint traces of postmedial lines, edged with whitish at inner margin Hind wing below. Costa and basal half to below cell drab, irrorated with cinnamon drab, the inner margin white, a postmedial fuscous black shade narrower and intensely black at inner margin, outwardly edged broadly with white, termen similar to fore wing

Expanse, 72 mm.

Habitat.—Balsas, Mexico.

Type.—Cat. No 34461, U S. N M.

Nearest *H. lugens* Walk. Brighter colored with distinct black longitudinal lines, the postmedial white line on hind wing more deeply upcurved before inner margin.

Cautethia simitia, new species

Female.—Palpi below grayish white. Body above drab gray, irrorated with darker gray and hair-brown scales; abdomen with fine black segmental lines above, laterally on basal half light buff, underside whitish except on terminal three segments. Fore wing drab gray, irrorated with darker scaling; traces of subbasal black patches between veins; antemedial line double, black, outangled on median vein; a small linear quadrate black spot at discocellular, the inner edge more heavily marked, a faint dark line above it on costa, and a short black line on vein 5 beyond it; postmedial line black, outwardly edged with whitish scaling, dentate from costa to vein 3, below vein 3 straight, more heavily marked, and vertical to inner margin; terminal space with a double series of dull drab patches on interspaces, connected by grayish white scaling; a fine terminal benzo brown line expanding on interspaces. Hind wing: Basal half orange, distal half fuscous.

Expanse, 34 mm.

Habitat.—Simiti, Colombia.

Type.—Cat. No. 34445, U. S. N. M.

Conspicuous by the absence of the fuscous oblique streak at tornus of fore wing, present in all the other species.

SATURNIIDAE

Rothschildia coxeyi, new species

Female.—Head and collar pinkish cinnamon, the latter edged with white. Thorax orange cinnamon. Abdomen pinkish cinnamon; a narrow transverse white line at base, a lateral white line divided by a cinnamon buff line; legs pinkish cinnamon, partly streaked with white. Wings above to postmedial line orange cinnamon; postmedial fine, fuscous, lunular dentate, outwardly white, followed by a narrow fuscous shade irrorated with lilacine white, then by a broad pale grayish vinaceous space distally deeply dentate on veins, narrowly edged with russet. Fore wing: an antemedial white line distally edged with fuscous, outbent to median, then inbent to near base of inner margin, the hyaline spot basally incurved, distally rounded across postmedial line, below strongly inbent, partly edged by a very fine black line, outer space brown, below vein 6 broadly ochraceous orange, limited by a fine lunular black line, above vein 6 a large white and pallid vinaceous-drab space to costa and apex, outwardly edged with ochraceous orange, between veins 6 and 7 the subterminal line enclosing a triangular black spot and a broken English red line, termen tawny olive. Hind wing: An incurved black and white line near base; the hyaline spot basally incurved, almost angular, constricted before crossing postmedial line, the broad pale grayish vinaceous space not so conspicuously dentate as on fore wing, the outer space orange cinnamon thickly irrorated with brownish drab; subterminal line fine, black, almost straight preceded by Hay's russet spots, below middle of costa an elongated oval hyaline spot edged with white and then a black line. Wings below to postmedial line clay color, the broad space beyond postmedial paler than above and extending to apex, the interspaces towards margin below vein 6 cinnamon buff. No antemedial line on fore wing, the oval spot below costa of hind wing very distinct.

Expanse, 118 mm.

Habitat.—Macas, Ecuador.

Type.—Cat No 34376, U S. N M.

Named in honor of its discoverer, W. Judson Coxey.

The whole appearance of the species is very distinct

Automeris semicaeca, new aberration

Male —Antenna, head, and collar cinnamon, thorax and abdomen above orange cinnamon; body below light pinkish cinnamon Fore wing acute, somewhat falcate, orange cinnamon, the terminal space beyond line brownish vinaceous; lines light vinaceous cinnamon, antemedial vertical, inwardly dark edged, outer line from costa near apex to beyond middle of inner margin outwardly dark edged, a fine, small, dark annulus at discocellular filled in with light vinaceous cinnamon Hind wing russet vinaceous; a small white spot at discocellular with a pointed dash of white scales extending from it distally, a fine subterminal lunular black line followed by a broader brazil red parallel line, termen narrowly light pinkish cinnamon. Fore wing below somewhat paler, more of a brownish vinaceous shade, a round black spot at discocellular containing a small white spot; outer line black, faintly wavy Hind wing below russet vinaceous, suffused with pinkish cinnamon, a faint darker postmedial line, no discal spot

Expanse, 72 mm

Habitat —Santa Catharina, Brazil

An abberation of the reddish form of *Automeris memusae* Walker.

Hylesia coarya, new species

Male —Antenna with red shaft and orange pectinations Head, collar, and thorax purplish fuscous Abdomen above raw sienna with transverse brussels brown lines, underneath vinaceous drab Wings vinaceous drab Fore wing. A thick fuscous line from base of costa, outbent to inner margin; a fine dark medial line outcurved to vein 2, then slightly outbent, suffusing with the similar postmedial line at inner margin, the postmedial outcurved on costa, then straight and inbent, a thick dark line on discocellular, the veins from medial line to termen finely darker, a pallid purple drab spot at apex Hind wing A faint darker medial shade, its edge dentate on veins, a faint subterminal shade Wings below somewhat darker, the hind wing with a darker line from costa near apex to above middle of inner margin; the subterminal shade as above

Expanse, 34 mm

Habitat —Coary, Amazons

Type —Cat No 34463, U S. N M

The apex of fore wing slightly produced, rounded

Hylesia cottica, new species

Male —Antenna ochraceous buff Head and thorax chaetura drab; abdomen mars brown, mottled with light buff hairs and with fuscous segmental lines Fore wing hair brown, the medial space paler, the lines and veins finely darker, antemedial line very faint, vertical, the postmedial inbent; a faint dark shade on discocellular; a small pale smoke gray spot above vein 7 on termen, inner margin narrowly fuscous Hind wing the same shade as medial space of fore wing, the inner margin with long darker hairs; faint traces of a subterminal line Wings below of a uniform duller color A distin-

guishing feature is the shape of the fore wing: The apex is bluntly produced and the termen more inbent than in the usual run of species, so the wing appears longer and narrower.

Expanse, 39 mm

Habitat.—Moengo, Cottica River, Surinam

Type—Cat No 34464, U S N M

Hylesia huyana, new species

Female.—Head and thorax brownish drab Abdomen cinnamon buff with clay color segmental lines Fore wing light cinnamon drab, the terminal space pale ecru drab, an irregular darker subbasal line, a fine lunular antemedial line, a white line on discocellular; a fine dark somewhat lunular line from costa near apex to middle of inner margin Hind wing light cinnamon drab, the veins finely darker, a fine dark line on discocellular, traces of a straight postmedial line from costa before apex to middle of inner margin, more distinct on underside. Fore wing below somewhat paler than above, the markings visible in transparency The termen is more oblique than usual in Hylesia.

Expanse, 70 mm

Habitat—Yahuarmayo, Peru

Type—Cat No 34469, U S N M

Hylesia ileana, new species

Male—Palpi burnt sienna Head, collar, and tegulae cacao brown, the thorax walnut brown. Abdomen above grayish cinnamon, underneath clay color Fore wing· Base russet vinaceous limited by a darker vertical antemedial line, medial space wider on costa than on inner margin, light russet vinaceous with a large oval russet vinaceous spot on discocellular, postmedial line vinaceous brown, slightly outcurved on costa, and inbent to inner margin, terminal space russet vinaceous, crossed by a subterminal light russet vinaceous shade from apex to tornus somewhat interrupted opposite cell, cilia kaiser brown Hind wing deep brownish vinaceous, the veins finely darker, termen light russet vinaceous Wings below deep brownish vinaceous, the veins darker The fore wing is slightly produced at apex, but not acute

Expanse, 36 mm

Habitat—Chiapas, Mexico

Type—Cat No 34462, U S N M

The paratypes are in the collection of Don Carlos Hoffmann, Mexico City

Hylesia orbana, new species

Male.—Antenna cinnamon Collar and thorax purple drab Abdomen dull cinnamon, mottled with purple drab hairs on segments, leaving dull cinnamon segmental lines, ventral surface purple drab Fore wing purple drab; some small antemedial pallid purple drab spots, postmedial line outcurved at costa, slightly inbent below vein 5, defined by irregular pallid purple drab scaling; a large fuscous spot at end of cell, some pale scaling on termen above vein 7 Hind wing largely purple drab, the costa paler, a postmedial and terminal light purple drab shade Fore wing below darker, a dark streak on discocellular; postmedial and terminal paler shading Hind wing below light cinnamon drab with darker postmedial and subterminal shading.

Female darker, the markings more of a dusky brown with fuscous suffusions at base; discal spot broader, not so round; postmedial shade broad; the termen darker shaded Hind wing with darker veins and a curved line on discocellular.

Expanse, Male 52 mm , female 57 mm.

Habitat —Boven, Surinam.

Type —Cat No 34466, U S N. M.

Allied to *H mixtiplex* Dognin.

Dysdaemonia avangareza, new species

Female —Palpi and head benzo brown Collar and thorax tilleul buff. Abdomen above ecru drab, underneath buffy brown; legs brownish drab. Fore wing tilleul buff suffused with avellaneous; faint traces of an outbent wood brown antemedial line; a double wood brown line widely separated, from near middle of costa, slightly excurved to the postmedial line at inner margin; a fine pale line on discocellular defined by cinnamon brown edging, followed by two elongated, large hyaline spots also finely edged with cinnamon brown, the spots distally rounded, the upper spot only slightly smaller and narrower; a fine vertical postmedial line, buffy brown, intercepted by the hyaline spots, the space beyond to outer line light cinnamon drab, outer line well marked, hair brown, outcurved below costa and inbent to postmedial line on inner margin, outer line irregularly followed by light vinaceous fawn; a large army brown spot on costa not reaching apex, its proximal edge incurved, its distal edge sinuous; some triangular fuscous brown spots from vein 3 to inner margin close to outer line, termen suffused with army brown from apex to below vein 3 expanding at vein 4; the crenulate margin mostly edged with cinnamon brown Hind wing: Base as on fore wing, a faint darker antemedial line vertical from costa, curved just above postmedial and upbent to inner margin, broader and diffuse; post-medial line benzo brown outwardly shaded with dusky drab then light cinnamon drab to outer line, the latter buffy brown, broad to vein 6, then inbent fuscous, narrowing to inner margin, termen broadly pale vinaceous fawn, some army brown clusters of scales from below vein 3 to inner margin close to outer line, some subterminal army brown shading from costa to vein 6; termen narrowly suffused with army brown Wings below cinnamon drab Fore wing· The outer line buffy brown, not so outcurved at costa; postmedial line very faint. Hind wing: Postmedial line fawn color, outer line darker.

Expanse, 131 mm

Habitat —Avangarez, Costa Rica

Type —Cat No 34417, U S N M.

Dysdaemonia guyaquila, new species

Female.—Palpi and head benzo brown Collar and thorax vinaceous buff Abdomen cinnamon drab Fore wing· Costa mostly vinaceous fawn, mottled with drab, a dark line on base of median, space below light vinaceous fawn, covered with long hairs, outwardly limited by an outbent antemedial army brown line from below cell to inner margin; a sinuous outbent medial line from subcostal, preceded by light vinaceous fawn scaling, and broadly followed by fawn color which joins the postmedial line below vein 3, the space above it to costa light vinaceous fawn enclosing two hyaline spots, the upper spot quite small, neither of them with any edging; a fine dark line on discocellular with verona brown points at upper and lower angle of cell; post-

medial line mikado brown, slightly sinuous, and passing beyond the hyaline spots, outwardly shaded with sayal brown to near outer line which is fine, fuscous, outcurved at costa where it is preceded by some light vinaceous fawn scaling, on costa before apex an irregular Hay's russet spot; termen at apex light vinaceous fawn, otherwise largely deep brownish drab; beyond outer line a series of triangular liver brown spots on interspaces, except between veins 4 and 6; the spot above vein 6 more elongated, all these spots edged with light brownish drab. Hind wing from base to postmedial light brownish drab, the inner margin with long light vinaceous fawn hairs; from below cell an antemedial fawn color fascia curved to inner margin, postmedial line hazel, broadly shaded distally with cinnamon rufous, outer line faint from costa, from vein 5 to inner margin black, followed by light brownish drab; a subterminal series of dark spots coalescing towards costa; outer margin light vinaceous fawn, the termen from projection below vein 5 hazel. Fore wing below cinnamon drab, dark from postmedial to outer line; termen suffused with light vinaceous fawn Hind wing below avellaneous to postmedial line; the outer line distally edged with light vinaceous fawn; some similar shading on termen.

Expanse, 132 mm

Habitat.—Guayaquil, Ecuador

Type—Cat No 34416, U S N M.

Copiopteryx phippsi, new species

Male.—Palpi and a line behind head blackish brown Head pale pinkish cinnamon. Collar pinkish buff with a fine transverse sayal brown line. Thorax sepia, the shoulders avellaneous, mottled with vinaceous fawn. Abdomen above natal brown, underneath drab with a double hair brown line on basal half. Fore wing above. Costal margin on basal fourth pinkish buff with drab mottling, base below subcostal broadly sepia united by an ecru drab antemedial line, obliquely outcurved in cell, below cell slightly outbent and somewhat incurved above inner margin, this line outwardly edged by a fine dark line which extends on to costa as a black outangled line, from this line at subcostal a snuff brown line is outbent and curved to lower angle of cell, then upbent to a point on vein 4, is there upbent to costa, and downcurved to inner margin forming the postmedial line, the large space enclosed above it pale vinaceous fawn, irrorated with light drab, chiefly on costa, on this space is a small triangular hyaline spot, edged outwardly by a snuff brown sinuous fascia which extends above it to subcostal, the medial space below the line verona brown, suffused with brownish drab along the antemedial line, and before the postmedial from vein 2 to inner margin becoming pinkish buff, the postmedial line is followed by light drab, broadly from costa to vein 6, limited by a fine, wavily outcurved, dark line which is incurved below vein 6 and becomes black following closely the postmedial to inner margin, the light drab preceding it forming a broad line, partly edged with pinkish buff, the outer dark line is followed by narrow hyaline spots from above vein 5 to below vein 4; termen from costa to vein 5 suffused with drab and buffy brown; below vein 5 to near vein 3 a dark vinaceous brown shade, inner edge sinuous and excurved towards vein 3, terminal space above tornus pale vinaceous fawn, irrorated with drab, and with some dark points close to outer line; cilia mostly fuscous Hind wing: Costal half light cinnamon drab, inner margin to postmedial line army brown, a medial curved darker line below cell, above it at inner margin a light drab patch containing a small semilunar hyaline spot; postmedial

line army brown, broad, downbent, and sharply angled and upbent towards inner margin, this line followed by a second line well below apex, becoming fuscous and thicker, where downbent on tail, also sharply angled and upbent to inner margin; a light buff shade between the postmedial and marginal lines where angled; the fuscous line extending to beyond middle of tail, the terminal portion dark tilleul buff. Wings below light buff with cinnamon drab and hair brown striae Fore wing Traces of a postmedial line from costa, the outer line distinct from vein 5 to inner margin Hind wing with only the marginal lines

Expanse, 100 mm

Habitat —Province of Rio, Brazil.

Type.—Cat No 3440, U S N M

I take pleasure in naming this species in honor of Senator Phipps who contributed generously to the purchase of the Dognin collection where this fine species was found.

This species is somewhat like *C sonthonnaxi* André The termen from vein 6 to apex is wavy, below vein 6 more inbent and not so deeply crenulate as in *C sonthonnaxi* It is also allied to *C. virgo* Zikan

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

MEMORIAL RESOLUTION ON THE DEATH OF FRANK WIGGLESWORTH CLARKE

Dr F W CLARKE, one of the founders and a past president of the Washington Academy of Sciences and one of the stanchest supporters of its Journal peacefully passed away at his home in Chevy Chase, Maryland, on May 23, at the age of 84 In his death Science has lost a most notable and enthusiastic worker and the Academy one of its most distinguished and faithful members

Dr CLARKE believed in research in fundamental principles rather than in applied science, although he realized that both were necessary, for, as he was often heard to say "How can science be applied if there is no science to apply?" In 1872, at the age of 25, he advanced this principle when he submitted to the Smithsonian Institution his first manuscript on the *Constants of Nature* Again, in 1878, in his address as chairman of the section of chemistry of the American Association for the Advancement of Science, after expressing his adherence to this principle, he lamented the fact that so little support was given to the study of the basic truths of nature and especially mentioned the lack of cooperation in what little work was being done in his own science, saying "What chemistry needs is combined effort upon some general plan" Undoubtedly, CLARKE's repeated calls for close cooperation in scientific work materially influenced our present day attitude He advocated the establishment of governmental research laboratories with skilled specialists before any of the present ones came into existence

CLARKE's instinctive critical ability enabled him to evaluate rapidly the work of other people and his systematic procedure made him a notable compiler, as evidenced by his *Constants of Nature*, his many reports on atomic weights, and finally his *Data of Geochemistry*, which went through five editions. The best part of his life was spent as Chief Chemist of the U. S.

Geological Survey, a position he filled for many years from his appointment in 1883.

Always kind and generous he reflected only the bright side of life to his associates His witty and humorous remarks often helped to brighten the day for those who were in contact with him.

Now, Whereas, FRANK WIGGLESWORTH CLARKE, a past president of this Academy was long one of its most influential members and largely instrumental in reviving the publication of the Journal of the Academy in 1911, and

Whereas, he was recognized as an international authority on atomic weights and geochemistry, and was one of the first to compile tables of fundamental physical and chemical constants, so that by his death the Academy has sustained a distinct loss,

Therefore, be it resolved that the Academy express itself as appreciative of the high quality of his work and his long sustained interest in many varied fields of science And further, that the sympathy of the Academy be extended to his bereaved family, that these resolutions be published in the Journal, and that a copy be transmitted to his family

(Prepared for the Academy by W T SCHALLER, GEORGE STEIGER and R C WELLS)

NEWLY ELECTED MEMBERS OF THE WASHINGTON ACADEMY OF SCIENCES

FREDERICK EUGENE FOWLE, Research Assistant, Smithsonian Astrophysical Observatory, was elected to membership in recognition of his contributions to astrophysics and in particular his researches on the absorption of solar radiation by atmospheric water vapor and atmospheric ozone He has been Editor of the Smithsonian Physical Tables since 1910

Dr WILLIAM C FRAZIER, Senior Bacteriologist, Research Laboratories, Bureau of Dairy Industry, was elected to membership in recognition of his contributions to the science of bacteriology and especially to the metabolism of bacteria

Dr PAUL S GALTSOFF, Biologist in charge oyster fishery investigations, Bureau of Fisheries, was elected to membership in recognition of his contributions to experimental biology and in particular his researches on regeneration of sponges and physiology of Pelecypoda (Oyster)

ROY W GORANSON, Physicist, Geophysical Laboratory, was elected to membership in recognition of his work on density distribution in the earth's crust and his work on thermodynamic relations in multi-component systems

DR JOSEPH GRINNELL, Director, Museum of Vertebrata and Zoology, and Professor of Zoölogy, University of California, was elected to membership in recognition of his contributions to ornithology and zoogeography

J. N B. HEWITT, Ethnologist, Bureau of American Ethnology, was elected to membership in recognition of his researches among the Iroquoian Indian tribes, and particularly his work on the League of the Iroquois Nations

H. H T. JACKSON, Senior Biologist, Bureau of Biological Survey, was elected to membership in recognition of his contributions to systematic mammalogy

DR. CARL CLARENCE KIESS, Senior Physicist, Bureau of Standards, was elected to membership in recognition of his work on the description and classification of spectra, comet and planetoid orbit observations and stellar spectra

Dr ALBERT E LONGLEY, Associate Botanist, Division of Genetics and

Biophysics, Bureau of Plant Industry, was elected to membership in recognition of his work in cytology.

Dr D. J McADAM, JR, Senior Metallurgist, Bureau of Standards, was elected to membership in recognition of his contributions to physical metallurgy and his studies of the corrosion of metals.

Dr HARRY JOHN McNICHOLAS, Physicist, Bureau of Standards, was elected to membership in recognition of his work in optics, colorimetry, reflectometry and spectrophotometry.

THOMAS P. PENDLETON, Chief Engineer, Aerotopograph Corporation of America, Washington, D C, was elected to membership in recognition of his research and contributions to stereophotogrammetry as applied to phototopographic surveying and mapping.

JAMES LEE PETERS, Assistant in Birds, Museum of Comparative Zoölogy, Cambridge, Mass, was elected to membership in recognition of his contributions to systematic ornithology.

Dr. JOSEPH H ROE, Professor of Biochemistry, George Washington University, was elected to membership in recognition of his contributions to biochemistry and in particular his researches on the chemistry of blood

Dr F D ROSSINI, Associate Scientist, Bureau of Standards, was elected to membership in recognition of his contributions to chemical thermodynamics.

KNOWLES RYERSON, Principal Horticulturist in Charge, Division of Foreign Plant Introduction, Bureau of Plant Industry, was elected to membership in recognition of his contributions to tropical and sub-tropical horticulture and in particular his services as head of the plant introduction work of the U S Department of Agriculture

Dr C. L SHEAR, Principal Pathologist in Charge, Division of Mycology and Disease Survey, Bureau of Plant Industry, was elected to membership in recognition of his contributions to mycology and plant pathology.

Dr A H STANG, Senior Materials Engineer, Bureau of Standards, was elected to membership in recognition of his work in determining the strength and other properties of engineering materials

Dr GEORGE TUNNELL, Petrologist, Geophysical Laboratory, was elected to membership in recognition of his work on the phase-relations in systems containing iron oxide and copper oxide

ANTHROPOLOGICAL SOCIETY

The Anthropological Society of Washington at its annual meeting held on January 19, 1932, elected the following officers for the ensuing year: *President:* J N B. HEWITT, Bureau of American Ethnology, *Vice-president* MATTHEW W STIRLING, Bureau of American Ethnology; *Secretary.* FRANK H. H. ROBERTS JR, Bureau of American Ethnology, *Treasurer* HENRY B. COLLINS JR, U. S National Museum: *Representative of the Anthropological Society to serve as one of vice-presidents of the Washington Academy of Sciences.* N. M. JUDD, U. S. National Museum; *Members of the Board of Managers:* BIREN BONNERJEA, Catholic University, GEORGE S. DUNCAN, American University; HERBERT W. KRIEGER, U S. National Museum; FRANK M. SETZLER, U. S. National Museum; WILLIAM DUNCAN STRONG, Bureau of American Ethnology

The following is a report of the membership and activities of the Society since the last annual meeting, held January 20, 1931.

Membership.

Life members		4
Active members		56
Associate members		6
Honorary members		23
Corresponding members		22
Total		111
Deceased during year		5
Associate	1	
Active	3	
Life	1	
Resigned, active		1
New Members, active		2

Financial Statement.

Funds invested in Perpetual Building Association	$1057 93
21 Shares Washington Sanitary Improvement Co., $10 par	210 00
2 Shares Washington Sanitary Housing Co, $100 par	200 00
Cash on hand	245 75
Total	$1713 68
Bills payable	5 80
Net Balance	$1707 88

Papers presented before regular meetings of the Society were as follows:

January 20, 1931 *Two Small Pueblo Ruins in the Zuñi Region*, by FRANK H. H. ROBERTS JR., archeologist, Bureau of American Ethnology.

February 17, 1931. *Archeological Explorations on St Lawrence Island, Alaska*, by HENRY B COLLINS JR., assistant curator of ethnology U. S National Museum

March 17, 1931. *The Mound-Builder Cultures of the Upper Mississippi Valley*, by FRANK M SETZLER, assistant curator of archeology, U S. National Museum.

April 21, 1931 *An Archeological Reconnaissance of the Hawaiian Islands*, by W. M. WALKER, associate anthropologist, Bureau of American Ethnology.

October 20, 1931 *Prehistoric Peoples of the Middle Missouri Valley*, by WM. DUNCAN STRONG, ethnologist of the Bureau of American Ethnology.

November 17, 1931. *The Cultural Background of the Present Situation in India*, by BIREN BONNERJEA, Professor of Bengali and Hindustani, Foreign Mission School at Catholic University

December 15, 1931. *The Indians of the North Pacific Coast*, by EDWARD SAPIR, professor in anthropology, Yale University This talk was the first in a series of five special lectures relating to the Indian tribes of western North America The remaining four lectures were scheduled for the first part of 1932.

All of the meetings, with the exception of that held December 15, were in Room 42–43 of the new U. S. National Museum. The meeting of December 15th was held in the large auditorium of the same building. In accordance

with the custom of several year's standing all of the meetings held in January, February, March and April took place at 4:45 P.M. Beginning with the October meeting the time was changed to 8:00 P.M. The wisdom in this step was shown by the increase in attendance Where the afternoon meetings had an average of 25, the evening gatherings passed the 50 mark. The special lecture by Dr. SAPIR had an attendance of 160.

The Society was unfortunate in its loss by death of five members. Dr. GEORGE A. DORSEY, associate member, died March 29, 1931. Mr. VICTOR J. EVANS, an active member, died February 1, 1931. Dr. GEORGE M. KOBER, life member, died on April 24, 1931. Mrs LOUISE SIMPSON, active member, died in March 1931. Dr. HERMAN F. C. TEN KATE, active member, died February 4, 1931.

FRANK H. H. ROBERTS JR , *Secretary.*

Obituary

General GUSTAVE AUGUSTE FERRIÉ (born Nov. 19, 1868) died in Paris on Feb 16, 1932, following an operation for appendicitis. He was Inspector General of the Military Telegraphic Service of France, Member of the Institute of the Academy of Sciences, and Commander of the Legion of Honor. He visited Washington in 1927, when he was President of the International Radio Congress held in this city.

Several institutions in Washington, notably the U. S Coast and Geodetic Survey and the U. S. Naval Observatory, have been closely associated with Gen. FERRIÉ in international coöperative work of a scientific character. This was especially the case in 1926, when they cooperated with him in the world longitude determinations, planned and executed under the direction of Gen. FERRIÉ, which were designed to test the Wegener hypothesis

Dr FERDINAND CANU, paleontologist of Versailles, France, and known in the United States especially for the series of monographs on fossil and recent bryozoa published by the United States National Museum, died suddenly February 12, at his home, age, 69 years As a teacher of science in the Paris schools, he became an authority on meteorology and paleogeography Later he took up the study of the bryozoa and became the leading specialist in this field. In 1912 began the joint studies with R S BASSLER upon American fossil bryozoa which have continued uninterruptedly until the present and have made the National collections of these organisms one of the largest extant.

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MATHEMATICAL PHYSICS.—*On the application of Appell's equations.*[1] MARGARET WHEELER, Washington, D. C. (Communicated by EDGAR W. WOOLARD).

Both Lagrange's equations and Appell's equations describe the motion of a body or system of bodies. The latter are the more general in that they may be applied directly to non-holonomic, as well as holonomic, systems; a system being holonomic when the number of degrees of freedom is the same as the least number of distinct coördinates, and non-holonomic when the number of degrees of freedom is less than the least number of distinct coordinates. But this advantage of Appell's equations is merely theoretical since Lagrange's equations may easily be modified to apply to non-holonomic problems. Moreover, the mathematical difficulties in the application of Appell's equations to simple holonomic problems make them less useful. The question arises as to whether Appell's equations have any practical advantages at all. There is one, viz., their application to holonomic systems with cyclic coordinates.

Suppose we have a holonomic, dynamic system of n particles whose motion may be described by k distinct coordinates represented by q_κ ($\kappa = 1, 2, \ldots, k$). Define $T \equiv \sum_{i=1}^{n} \frac{m_i}{2}\left[\dot{x}_i^2 + \dot{y}_i^2 + \dot{z}_i^2\right]$. Then Lagrange's equations may be written:

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_\kappa}\right) - \frac{\partial T}{\partial q_\kappa} = Q_\kappa$$

The "energy of accelerations" is defined as $S \equiv \sum_{i=1}^{n} \frac{m_i}{2}\left[\ddot{x}_i^2 + \ddot{y}_i^2 + \ddot{z}_i^2\right]$

[1] Received January 27, 1932

and we write Appell's equations as

$$\frac{\partial S}{\partial q_\kappa} = Q_\kappa \quad \text{or} \quad \frac{\partial S'}{\partial q_\kappa} = Q_\kappa$$

where S' includes only the terms in S involving the accelerations. The Q_κ's are determined by computing the virtual work, $Q_\kappa \delta q_\kappa$. Since both Lagrange's and Appell's equations apply directly to holonomic systems, we have the identity

$$\frac{\partial S'}{\partial q_\kappa} \equiv \frac{d}{d\,t}\left(\frac{\partial T}{\partial \dot{q}_\kappa}\right) - \frac{\partial T}{\partial q_\kappa} = Q_\kappa$$

A cyclic coordinate is defined as one which does not appear explicitly in T, that is, it appears only in its derivatives. Suppose there are l cyclic coordinates leaving $k - l$ non-cyclic coordinates. The condition for a cyclic coordinate in T may be stated as $\frac{\partial T}{\partial q_\lambda} = 0$, $(\lambda = 1, 2, \ldots, l)$. Then the above identity reduces to

$$\frac{\partial S'}{\partial q_\lambda} \equiv \frac{d}{d\,t}\left(\frac{\partial T}{\partial \dot{q}_\lambda}\right)$$

Let p_λ represent the momentum of a cyclic coordinate. Then since $\frac{\partial T}{\partial \dot{q}_\lambda} = p_\lambda$, $\frac{\partial S'}{\partial \ddot{q}_\lambda} = \dot{p}_\lambda$. For holonomic systems $\frac{\partial S'}{\partial \ddot{q}_\lambda}$ will always be integrable since it is identical with $\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{q}_\lambda}\right)$ In order to identify a cyclic coordinate in S' we define it as one which does not appear explicitly in S' and then show that this definition is equivalent to the definition for a cyclic coordinate in T.

Whether or not a coordinate be cyclic depends upon how the Cartesian coördinates are expressed in terms of the generalized coordinates. When the Cartesian coordinates are expressed as rational, algebraic functions of the generalized coordinates, it is easily seen by inspection that a coordinate will be cyclic in both T and S' when the relationship is linear and non-cyclic in both for cases of higher degree. We find by trial that it is impossible to obtain a cyclic coordinate in T or S' for a logarithmic or exponential function unless the latter be expressed as a particular trigonometric function. We shall now consider this case.

Let $$x = a \sin q$$

Then $$x = a \cos q\, q$$

$$x = a \cos q\, q - a \sin q\, q^2$$

It is evident that x and x^2 will always contain the coordinates for any function of this type. Consider the case, however, when

$$x = a \sin q$$

$$y = a \cos q$$

$$z = 0$$

We obtain the following expressions for T and S'.

$$T = \frac{m}{2} [a^2q^2 (\sin^2 q + \cos^2 q)] = \tfrac{1}{2} ma^2q^2$$

$$S' = \frac{m}{2} [a^2q^2 (\sin^2 q + \cos^2 q)] = \tfrac{1}{2} ma^2q^2$$

This is probably the only way in which we may obtain a cyclic coordinate for a trigonometric function; that is, by the combination of (sine)^2 and (cosine)^2 terms The function above is very simple, but we find that we obtain a cyclic coordinate for complex functions provided the cyclic coordinate bears the same relationship to x, y, and z. For example, q_1 will be cyclic in T and S' if

$$x_i = f(q_2, q_3, \quad , q_k) \sin q_1$$

$$y_i = g(q_2, q_3, \quad , q_k) \cos q_1$$

$$z_i = h(q_2, q_3, \quad , q_k)$$

Since a coordinate is cyclic in S' when it is cyclic in T for all these representative functions, we conclude that our definitions of a cyclic coördinate in T and S' are equivalent.

The greatest advantage of the use of a cyclic coordinate is found in the case of ignorable coordinates, a special type of cyclic coordinate obtained when $Q_\lambda \delta q_\lambda$ vanishes. This is true when $Q_\lambda = 0$. For a cyclic coördinate $\frac{\partial S'}{\partial q_\lambda} \equiv p_\lambda = Q_\lambda$ and p_λ is constant for an ignorable

coördinate. For Lagrange's equations Routh has introduced a modified function by which we may ignore those coördinates having constant momenta. Routh's modified function is

$$M \equiv T_p - \sum_{\lambda=1}^{l} p_\lambda \dot{q}_\lambda$$

where T_p is a function of the coördinates and the momenta. Suppose that all the cyclic coordinates are ignorable. Then we may substitute the constant values of the momenta, a_λ, for p_λ.

$$M \equiv T_p - \sum_{\lambda=1}^{l} a_\lambda q_\lambda$$

Let $\mu = l+1, l+2,$, k, since there are $k - l$ non-cyclic coordinates. Then the equations of motion for the non-cyclic coördinates in terms of the modified function are

$$\frac{d}{dt}\left(\frac{\partial M}{\partial q_\mu}\right) - \frac{\partial M}{\partial q_\mu} = Q_\mu$$

Thus we have reduced the number of equations to be solved simultaneously from k to $k - l$.

In Appell's equations, S' is a function of all the velocities, accelerations, and non-cyclic coördinates. We have $2l$ equations expressing p_λ and $\dot{p}_\lambda$ in terms of the coordinates, velocities and accelerations. Therefore, we may express the l cyclic velocities and the l cyclic accelerations in terms of the cyclic momenta and non-cyclic coordinates, velocities and accelerations. When we substitute for q_λ and $\dot{q}_\lambda$ in S', we represent the new function by S'_p. Then

$$\frac{\partial S'_p}{\partial q_\mu} = \frac{\partial S'}{\partial q_\mu} + \sum_{\lambda=1}^{l} \frac{\partial S'}{\partial q_\lambda}\frac{\partial q_\lambda}{\partial q_\mu} \qquad \begin{array}{l}\lambda = 1, 2, \cdots, l \\ \mu = l+1, l+2, \cdots, k\end{array}$$

$$\frac{\partial S'}{\partial q_\lambda} = p_\lambda$$

$$\frac{\partial S'}{\partial q_\mu} = \frac{\partial S'_p}{\partial q_\mu} - \sum_{\lambda=1}^{l} p_\lambda \frac{\partial q_\lambda}{\partial q_\mu}$$

$$\frac{\partial S'}{\partial \dot{q}_\mu} = \frac{\partial}{\partial q_\mu}\left(S'_p - \sum_{\lambda=1}^{l} p_\lambda q_\lambda\right)$$

Define $$N \equiv S'_p - \sum_{\lambda=1}^{l} p_\lambda \, q_\lambda$$

$$\frac{\partial S'}{\partial q_\mu} = \frac{\partial N}{\partial q_\mu}$$

Appell's equations for the non-cyclic coordinates become $\dfrac{\partial N}{\partial q_\mu} = Q_\mu$, and we call N the modified function for Appell's equations.

For the cyclic coordinates we obtain two equations for each coordinate.

$$\frac{\partial S'_p}{\partial p_\lambda} = \frac{\partial S'}{\partial q_\lambda}\frac{\partial q_\lambda}{\partial p_\lambda} = p_\lambda \frac{\partial q_\lambda}{\partial p_\lambda}$$

$$\frac{\partial S'_p}{\partial p_\lambda} = \frac{\partial}{\partial p_\lambda}(p_\lambda \, q_\lambda) - q_\lambda$$

$$q_\lambda = -\frac{\partial}{\partial p_\lambda}\left(S'_p - \sum_{\lambda=1}^{l} p_\lambda \, q_\lambda\right)$$

$$\left.\begin{aligned} q_\lambda &= -\frac{\partial N}{\partial p_\lambda} \\ p_\lambda &= Q_\lambda \end{aligned}\right\} \text{the two equations for each coordinate}$$

In Routh's modified function we have p_λ while in N we have p_λ. We find a distinct advantage here for ignorable coordinates since $p_\lambda = 0$ and N, therefore, reduces to S'_p. To illustrate the advantage we may apply this to a free particle in a plane as follows

$$x = r\cos\theta$$

$$y = r\sin\theta$$

$$T = \frac{m}{2}\left[r^2 + r^2\theta^2\right]$$

$$S' = \frac{m}{2}\left[r^2 - 2rr\theta^2 + r^2\theta^2 + 4rr\theta\theta\right]$$

We see that θ is cyclic in both T and S'. Now suppose the force perpendicular to r vanishes so that we may ignore θ. Then by Routh's modified function we obtain

$$\frac{\mathrm{d}}{\mathrm{d}t}\left(\frac{\partial T}{\partial \theta}\right) \equiv \frac{\mathrm{d}}{\mathrm{d}t}\, p_\theta = \frac{\mathrm{d}}{\mathrm{d}t}\,(mr^2\theta) = 0 \qquad \text{since } \frac{\partial T}{\partial \theta} \equiv 0$$

$$mr^2\theta = a \text{ (a constant)}$$

$$\dot{\theta} = \frac{a}{mr^2}$$

$$T_p = \frac{m}{2}\left[r^2 + \frac{a^2}{m^2r^2}\right]$$

$$M \equiv T_p - p_\theta\theta = \frac{m}{2}\left[r^2 - \frac{a^2}{m^2r^2}\right]$$

$$\frac{\partial M}{\partial r} \equiv Mr \qquad \frac{\partial M}{\partial r} \equiv \frac{a^2}{mr^3}$$

$$\frac{\mathrm{d}}{\mathrm{d}t}\left(\frac{\partial M}{\partial r}\right) - \frac{\partial M}{\partial r} \equiv mr - \frac{a^2}{mr^3}$$

Let $R \equiv$ force along the radius.

$$mr - \frac{a^2}{mr^3} = R$$

We obtain the same equation by using the function N as follows:

$$\frac{\partial S'}{\partial \theta} \equiv \dot{p}_\theta = mr^2\theta + 2mrr\theta = 0$$

$$p_\theta = mr^2\theta = a$$

$$\dot{\theta} = \frac{a}{mr^2} \qquad \ddot{\theta} = -\frac{2ra}{mr^3}$$

$$N \equiv S'_p = \frac{m}{2}\left[r^2 - \frac{2ra^2}{m^2r^3} + \frac{4r^2a^2}{m^2r^4} - \frac{8r^2a^2}{m^2r^4}\right]$$

$$\frac{\partial N}{\partial r} \equiv mr - \frac{a^2}{mr^3} = R$$

The process is shortened in comparison to Routh's method since $N \equiv S'_p$.

We may also compare the advantages of Appell's and Lagrange's equations in the case of a cyclic system. A cyclic system in T is defined as one for which T may be represented approximately by a homogeneous, quadratic function of the cyclic velocities In the case of a free particle in a plane, θ is cyclic and r is non-cyclic in T, for

$$T = \tfrac{1}{2}\, m\, [\dot{r}^2 + r^2\dot{\theta}^2]$$

If we suppose that r is small enough so that $\dot{r}^2$ may be neglected in comparison with $r^2\dot{\theta}^2$ we obtain $T_\lambda = \frac{1}{2}\, mr^2\dot{\theta}^2$ where $T_\lambda \equiv$ cyclic system in T.

Lagrange's equations for a cyclic system become

$$-\frac{\partial T_\lambda}{\partial q_\mu} = Q_\mu$$

$$\frac{d}{dt}\left(\frac{\partial T_\lambda}{\partial \dot{q}_\lambda}\right) = Q_\lambda$$

For the above system we have

$$-\frac{\partial T_\lambda}{\partial r} \equiv -\, mr\dot{\theta}^2 = R$$

$$\frac{d}{dt}\left(\frac{\partial T_\lambda}{\partial \dot{\theta}}\right) \equiv \frac{d}{dt}\,(mr^2\dot{\theta}) = r\Theta$$

To obtain a cyclic system of the same type as above for Appell's equations we must neglect any term in S' containing only r. We find, if $S'_\lambda \equiv$ cyclic system in S', the following:

$$S'_\lambda = \frac{m}{2}\,[2r\ddot{r}\dot{\theta}^2 + r^2\ddot{\theta}^2 + 4r\dot{r}\dot{\theta}\ddot{\theta}]$$

$$\frac{\partial S'_\lambda}{\partial \ddot{r}} \equiv -\, mr\dot{\theta}^2 = R$$

$$\frac{\partial S'_\lambda}{\partial \ddot{\theta}} \equiv \frac{d}{dt}\,(mr^2\dot{\theta}) = r\Theta$$

We see that these equations are identical with those obtained by a cyclic system in Lagrange's equations. There are two cases in which the two approximations would be identical; namely, when r is constant and $r = r = 0$, or when r is constant and very small so that $r = 0$. Since r must always be small even though not constant, it could vary over only a small range so that r would have to be small. However, r would not necessarily be of the same order of magnitude as r.

Lagrange's equations, without doubt, have an advantage over Appell's equations for obtaining the equations of motion of a system. But this is only the first step in problems of dynamics Far more difficult is the second one—integrating them. Cyclic and ignorable coordinates aid in the integration by the reduction of the number of equations to be solved simultaneously, and we have found that they are as readily recognized in the S' function as in the T function. Furthermore, we have seen that we need to compute only $S'_p \equiv N$ in place of the complete modified function for ignorable coordinates so that it is really easier to apply Appell's equations than Lagrange's equations in this case

For the opportunity to do this work the writer is indebted to a Sanders Fellowship in Physics at The George Washington University.

BOTANY.—*A new species of* Adenostegia *from Death Valley, with notes on calyx structure in the genus.*[1] C. V. MORTON, U. S. National Museum. (Communicated by FREDERICK V. COVILLE).

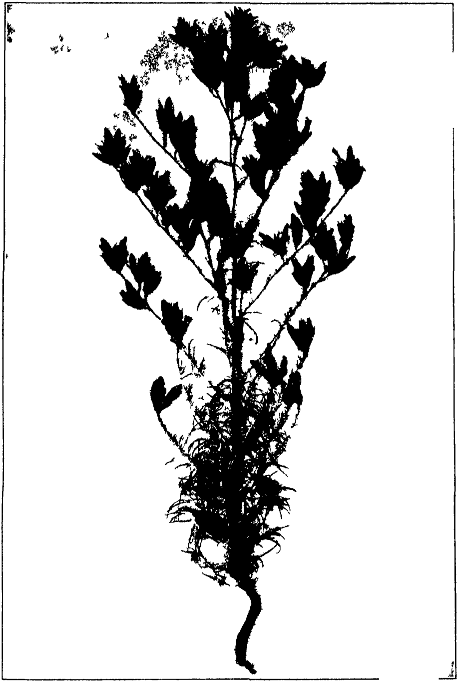
Dr Frederick V Coville, botanist of the Death Valley Expedition, 1891, revisited that locality in the interest of the National Geographic Society in April, and again in September, 1931. Among the plants of his recent collection is a species of *Adenostegia* (Scrophulariaceae), which is here described as new. A revision of this genus was published in 1918 by Mrs Roxana Stinchfield Ferris, of Stanford University,[2] and most of the specimens in the U. S. National Herbarium are annotated by Mrs. Ferris. All species of the genus are there represented, most of them by material of the type collections. The plant collected by Dr. Coville may be described as follows:

[1] Published by permission of the Secretary of the Smithsonian Institution. Received February 5, 1932

[2] "Taxonomy and distribution of *Adenostegia*," Bull Torrey Club **45** 399–423, *pl. 10–12* 1918.

Adenostegia eremica Coville & Morton, sp nov

Herba annua 20–30 cm. alta, valde sed stricte ramosa, ramis brevibus ex angulo acuto ascendentibus, inferioribus dense purpureo-griseo-puberulis, supremis plerumque flavido-viridibus; folia ad basin ramorum inferiorum in lobis nonnullis anguste linearibus valde partita, folia ad basin ramorum superiorum trifida, lobis linearibus revolutis, folia ramorum simplicia numerosa recurva anguste linearia 10–30 mm longa, apicem ramorum versus minora et bracteiformia, ca 1 2 mm. lata, perspicue revoluta, apice glandulam gerentia, folia omnia dense puberula, pilis minutis apice recurvis hyalinis, ex 2 vel 3 cellulis constatis, 80–240μ longis, basi 17–30μ latis, apicem versus acuminatis (raro acutis), hic 4–6μ latis, inflorescentia spicata, rhachi haud ramosa, floribus congestis sessilibus, capitulis 1–8-floris, in ramis inferioribus solitariis terminalibus, in ramis superioribus plerumque numerosis (usque 9), plus minusve secundis (propter pedunculos tortiles), pedunculus brevis, 10–15 mm. longus, foliis bracteiformibus numerosis puberulis parvis (2–4 mm. longis), inferioribus simplicibus linearibus, superioribus trifidis, omnibus apice glandulam gerentibus instructus, bracteae inferiores basi solum inflorescentiae, haud cum floribus adspersae, concinne palmatipartitae, pleraeque in 5 lobis, 2–7 mm longis, linearibus apice paullo incrassatis glanduliferis, interdum 2 lobis extremis semel furcatis divisae, puberulae, apicem loborum versus pilis granosis brevibus acriter acuminatis 2 vel 3 cellulis, usque 80μ longis, basi valde dilatatis hic usque 56μ latis, et pilis glanduliferis brevissimis, glandula lutea transverse ellipsoidea ca 17μ alta, 35μ lata, pedicellis 2 cellulis hyalinis, 20–25μ longis adspersis, basin bractearum loborumque versus pilis hyalinis nec granosis valde elongatis tenuibus usque ad 1090μ longis (plerisque minoribus), apice ca 7μ latis, basi non dilatatis, 17–36μ latis instructae, bracteae superiores, id est, eae flores amplectentes, oblongae, 10–15 mm longae, 4-4 5 mm latae, integrae (vel perraro in 1 vel 2 lobis lateralibus parvis incisae), vix carinatae saccataeve, apice acutae vel plus minusve rotundatae glandulam dorsalem gerentes, 5-nervatae nervis satis prominentibus, purpureae vel flavido-virides, ciliatae, pilis hyalinis pluricellularibus interdum longissimis (usque 2 mm) basi non dilatatis, intus glabrae, extus puberulae pilis minutis, etiam scabrae pilis (praecipue in venis) bulbosis granosis satis numerosis ca 350μ longis, ex ca 4 cellulis constatis, 2 cellulis inferioribus valde dilatatis 140–200μ latis, cellulis terminalibus acriter acuminatis, lobus calycis spathiformis ambitu lanceolatus tubulosus antice profunde fissus, hic 1 5–3 mm altus hyalinus, postice 10–15 mm altus 7-9-nervatus, nervis nonnullis vix prominentibus, apice emarginatus vel bidentatus (dentibus usque ad 1 5 mm longis), puberulus et scaber, pilis cis bractearum superiorum similibus, corolla purpurascens tubulosa basi cylindrica sursum ventricosa bilabiata, labiis fere aequalibus, postico paullo longiore 15–18 mm (raro solum 10 mm) longo, apice perspicue uncinato stylum amplectente, antico saccato trilobo lobis brevis rotundatis, lobo medio emarginato, tubo corollae extus basi glabro, sursum piloso, pilis hyalinis ex ca 3 cellulis constatis, granosis, patentibus, ca 300μ longis, 21-25μ latis, apice solum acutis, stamina 4 didyma, filamentis liberis in medio corollae insertis dense albido-pilosis, antheris 2-locularibus, loculo superiore majore, 1 2–1 5 mm longo, perspicue ciliato, loculo inferiore divergente minore sed non abortivo ciliato, stylus glaber apice acriter uncinatus breviter exsertus, ovarium glabrum apice acutum; capsula membranacea glabra apice acuta ca 9 5 mm longa, semina in capsula ca 14, oblonga vel obovata, ca 2 mm. longa, 1 mm lata, in tota superficie arcte et perspicue favosa



ADENOSTEGIA EREMICA Coville & Morton sp nov (Type specimen one half natural size)

Type in the U. S National Herbarium, no 1,530,679, collected near the crest of the Panamint Mountains, at the head of Death Valley Canyon, California, altitude about 3,000 meters, September 18, 1931, by Frederick V. Coville and Arthur F. Gilman (no 58). Duplicates of this collection have been presented to the Philadelphia Academy of Sciences and the New York Botanical Garden.

Additional collections are as follows: (1) Near the crest of the Panamint Mountains, at the head of Hanaupah Canyon, opposite Thorndyke's Camp, California, altitude about 2,800 meters, September 17, 1931, by F V Coville and A. F. Gilman (no 57), duplicates of this have been sent to Professor W L Jepson, Professor LeRoy Abrams, and the Santa Barbara Museum of Natural History; (2) Death Valley slope of the divide between Wild Rose Canyon and Hanaupah Canyon, Death Valley, California, altitude about 2,800 meters, September 15, 1931, by Coville and Gilman (no 28), a duplicate of this has been sent to the Gray Herbarium.

A preliminary study of Dr Coville's collection from Death Valley brought to light at once several interesting facts Mrs Ferris divides the genus into six sections. Excluding the sections *Anisocheila*, *Pringlea*, and *Dicranostegia*, which do not concern us, we are left with the three sections *Euadenostegia*, *Kingia*, and *Chloropyron* These are separated in the key to sections as follows.

Calyx diphyllous . . . . III *Euadenostegia.*
Calyx monophyllous

Inflorescence capitate . . . IV *Kingia.*
Inflorescence spicate . . . VI. *Chloropyron.*

In the first place it may be definitely stated that between *Kingia* and *Chloropyron* there is no difference in the inflorescence, which obviously is spicate in both cases. A more troublesome question arises with respect to the structure of the calyx Dissection of *A kingii* shows that the flower possesses a single calyx lobe of a spathaceous type on the posterior side, this lobe, which is deeply bidentate at apex, is nearly as long as the corolla and is sharply cut down anteriorly to a short tube scarcely two millimeters high Thus the calyx is definitely tubular at base, the anterior portion being very short and hyaline Originating directly below and partially surrounding this calyx is a bract, similar in texture and size but lobed toward the summit.

This, then, is the structure described as "calyx monophyllous" It was surprising therefore to find, on dissecting a flower of *A wrightii*, a species placed in the section *Euadenostegia*, identically the same structure, a single spathaceous calyx lobe partially surrounded at base by a lobed bract Yet the outer bract in this case is considered by Mrs Ferris as a lower calyx lobe and described as " tip lanceolate or two- to four-toothed " Examination of a series of specimens shows, however, that this outer bract is sometimes entire and sometimes (on the same plant) 3–5-lobed, the lobing being of exactly the same type as in *A kingii*, and consisting of a splitting away

of the parallel veins as they approach the apex. Each lobe therefore consists of a central vein and a varying amount of surrounding leaf tissue. Since there are five veins in each bract there can never be more than five lobes; three appears to be the commonest number.

Other species of the section *Euadenostegia* were next examined. They were all found to be of essentially the same structure, the outer bract surrounding the spathaceous calyx being usually entire. The distinctions between the sections as given by Mrs Ferris are therefore illusory, the calyx being monophyllous in all cases. These dissections showed at once that the section *Kingia* has no distinctive characters, the species *A. kingii* being in fact exceedingly close to *A wrightii*

The case of the section *Chloropyron* is also remarkable. In the species included in this section the upper calyx lobe is not tubular at base but is very similar to the entire bract inserted on the opposite side just below it This structure of the calyx and bract might much more reasonably be regarded as "diphyllous" than that in any of the sections of the genus, yet the species constituting this section have been described from the time of Asa Gray as "monophyllous," which is undoubtedly true This circumstance illustrates the general misunderstanding of the genus by authors

The genus was first proposed as *Adenostegia* by Bentham,[3] the calyx of his single species, *A rigida*, being described as "bifidus " Ten years later Bentham included the genus in his treatment of the Scrophulariaceae for the Prodromus[4] His description of the calyx reads "Calyx bipartitus segmentis integris, bracteis 4 incisis suffultus (vel 4-partitus bibracteatus?) Bracteae cum calycis laciniis 6, per para imbricatae, 2 exteriores (certe bracteae) trifidae foliis floralibus similes, 2 intermediae (an bracteae, an calycis segmenta") integrae bifidae vel exterioribus consimiles, 2 intimae (calycis segmenta) acute acuminatae lanceolatae carinatae concavae, 7–8 lin longae."

However, in the "Addenda et Corrigenda"[5] Bentham changes the name of the genus to *Cordylanthus* Nutt (Mss) and describes four species: *C filifolius* Nutt (=*Adenostegia rigida* Benth), *C. ramosus* Nutt., *C. capitatus* Nutt , and *C maritimus* Nutt The description of the calyx of *Cordylanthus* is as follows "Calyx bipartitus, segmentis complicatis integris vel postico breviter bifido " Under *C. maritimus* he says, " calycis lobo postico brevissime bifido " This latter statement indicates than Bentham did not consider the calyx of *C maritimus* essentially different from that of the other species

Asa Gray, however, in his revision of *Cordylanthus*[6] separated the genus into two sections, *Adenostegia* and *Hemistegia*, the first said to be " .

[3] Bentham in Lindley, Nat Syst ed II, 445 1836
[4] Bentham in DC Prodr 10 537. 1846
[5] DC Prodr 10 597 1846
[6] Proc Amer Acad 7 383 1868

calyx diphyllous," the latter "calyx monophyllous . " This imaginary distinction has been kept up by authors since Gray, including Wettstein,[7] who gives a very brief treatment of the genus based wholly on that of Gray's Synoptical Flora In Fig. 43, J. and K, Wettstein gives an illustration of the flower of "*Cordylanthus Nevinnyi* [sic!] A Gr" This drawing is so inaccurate that it seems impossible that the artist could have had a specimen of the species, *nevinii*, before him

Professor Jepson's descriptions[8] of the species of this genus indicate that he regards the calyx as consisting of one lobe only Thus he describes the calyx of *C. capitatus*, "calyx cleft to base anteriorly, 2-nerved, 2-cleft at apex posteriorly . ," and of *C nevinii*, "calyx tubular at base or obliquely cleft or parted on the anterior side nearly to base . " Moreover, his key departs from all previous keys to the species in not separating the subgenera by the character of the calyx being mono- or di-phyllous. On the other hand, in his key to the genera of Scrophulariaceae he separates *Cordylanthus* from *Castilleia* and *Orthocarpus* as follows "Calyx of 2 distinct divisions, or the upper division wanting" It is, of course, impossible ever to consider the *upper* division as wanting

Adenostegia eremica may be distinguished from related species by the following key:

Individual flowers bracteolate . **A. ramosa, A. rigida,** and others.
Individual flowers not bracteolate
  Sterile bracts at base of inflorescence several
    Sterile bracts symmetrically parted into comparatively broad lobes
      Inner bracts (i e those subtending flowers) entire **A. eremica.**
      Inner bracts conspicuously and symmetrically lobed . **A. helleri.**
    Sterile bracts irregularly parted into filiform lobes; inner bracts entire or irregularly lobed . . **A. wrightii.**
  Sterile bract at base of inflorescence solitary or absent, irregularly dissected into filiform lobes, inner bracts irregularly lobed **A. kingii.**

The species may be separated also by the following key based on the pubescence.

Hairs on leaves not glandular, dense, recurved, 80–240μ long, 17–30μ wide at base, acuminate at apex, here 4–6μ wide, calyx and subtending bract scabrous, the hairs bulbous, granular, about 350μ long, the two lower cells dilated 140–200μ wide, the two terminal acuminate **A. eremica.**
Hairs on leaves glandular at least in part, calyx and subtending bract without scabrous hairs
  Leaves (and whole plant) densely glandular, the glandular hairs with a 4-celled stalk, this about 70μ wide at base (tapering to the apex where

[7] Wettstein in Engl & Prantl, Pflanzenfam IV. 3b: 98 1895
[8] W L Jepson, Manual of the flowering plants of California 1925

25μ wide), and 240–500μ long; terminal yellow gland about 50μ wide . . . . **A. helleri.**

Leaves less conspicuously glandular, the stalk usually 3-celled, not over 35μ wide at base, not over 130μ long, the terminal gland not over 35μ wide . . . . **A. kingii** and **A. wrightii.**

BOTANY.—*A new* Dryopteris *from Cuba.*[1] CARL CHRISTENSEN, Botanisk Museum, Copenhagen.

Some time ago I received on loan from the U. S. National Museum, through Dr. William R. Maxon, several specimens of an interesting Cuban fern (*Dryopteris*), with the request that if it proved to be new, as Dr. Maxon believed, I should describe it, because of my special interest in the American species of this large genus. I did find it new, and offer here a description:

Dryopteris Santae Clarae C. Chr., sp. nov.

Ctenitis, e sectione *D. hirta*, ab speciebus omnibus hujus sectionis differt lamina basin versus sensim angustata (pinnis infimis 3–4 cm. longis) ubique dense glanduloso-pubescente, indusio parvo.

Rhizome oblique or decumbent, densely clothed with linear-lanceolate or lanceolate, long, acuminate, entire, castaneous scales. Stipe variable in length, usually 10–12 cm. long, densely crinite by narrow long hair-pointed scales (about 2 mm. long). Lamina lanceolate, 30–50 cm. long, 15–20 cm. broad at middle, narrowed toward both ends, herbaceous, densely glandulose-pubescent throughout by short pale glands and long articulated pale thin hairs (the hairs of rachis, costae, and veins rather longer, very soft), bipinnate-pinnatifid, rachis crinite like the stipe, but the scales much fewer, pinnae 12–15 pairs, subsessile, alternate, the basal ones 3–4 cm. long, the following ones (at distances of 5–6 cm.) gradually larger, the middle ones the largest, these 10–11 cm. long, 2.5–3 cm. wide, lanceolate, acuminate, pinnules in 15–18 pairs, the lower ones short-petiolulate, the upper adnate to costa and decurrent, the largest 2 cm. long, 1 cm. broad at base, deltoid, nearly pinnate at base (segments deeply pinnatifid), the middle ones 5 mm. broad at base, tapering toward the acute apex, incised nearly to the midrib into oblique, oblong, dentate or repand lobes, costae and costules furnished beneath with a few small, light brown, ovate-lanceolate, sometimes subbullate scales; veins oblique, not reaching the margin, sori supramedial, a little below the tip of the vein; indusia small, brown, subpersistent.

Type in the U. S. National Herbarium, no. 1,301,333, collected at La Siguanea, mountains of the Siguanea-Trinidad group, Province of Santa Clara, Cuba, on shaded perpendicular cliffs, February 14, 1924, by E. L. Ekman (no. 18462). The following additional specimens, all from the Province of Santa Clara, are at hand: Trinidad Mountains, alt. 470–1,050 meters, *Britton & Britton* 5101, *Britton & Wilson* 5298; *Jack* 7040, 7108, 7238, 7885; San Blas, alt. 180–240 meters, *Jack* 6508.

This new species of the group of *D. hirta*, which is very rich in forms in Hispaniola and Cuba, differs chiefly from the other West Indian species by

[1] Received February 15, 1932.

its leaf being considerably and gradually narrowed below. From its nearest relative, *D nemorosa* (Willd) Urban, it differs further in its dense pubescence, smaller indusia, and few bullate scales, or the scales sometimes wanting Like other species of this group, it seems to be local.

BOTANY.—*Marine algae from the islands of Panay and Negros (Philippines) and Niuafoou (between Samoa and Fiji).*[1] MARSHALL A. HOWE, New York Botanical Garden. (Communicated by WILLIAM R. MAXON)

In April, 1931, Dr. William R Maxon, Associate Curator, Division of Plants, of the United States National Museum, sent to the writer small collections of algae made by Lieut H. C. Kellers, M D , of the Medical Corps of the United States Navy, who was attached as surgeon to the Naval Eclipse Expeditions of 1929 and 1930. The specimens of algae, though excellent and well preserved with the aid of alcohol, were evidently incidental to more extensive collections of insects, reptiles, fishes, birds, amphibians, mammals, mollusks, echinoderms, corals, and other marine invertebrates, all of much scientific interest, as indicated in a preliminary way in the annual reports of the United States National Museum for the years 1930 and 1931.

Scattered references to the algae of the Philippine Islands have appeared in the earlier phycological literature. Blanco, in the two editions of his "Flora de Filipinas," 1837 and 1845, describes a dozen or more species of algae, more or less recognizable, using for the most part previously existing names, without citation of authorities More comprehensive was the report of G. von Martens on the algae of "Die Preussische Expedition nach Ost-Asien"[2] in 1866, in which 75 species were listed as occurring in the Philippines, including four from freshwater.

Dickie,[3] in a report on the algae of the Expedition of H. M. S. *Challenger*, enumerates 47 species from the Philippines.

Piccone[4] lists 9 species from the island of Ticao and 9 from Luzon (Cavite). A later paper by the same author[5] adds 2 species and one variety to this list.

In 1911, Dr. E. D. Merrill, then botanist of the Bureau of Science at Manila, forwarded to the present writer for determination a col-

[1] Received for publication March 2, 1932

[2] Bot Theil

[3] Journ Linn Soc Bot **15** 242-246 1876

[4] Alghe del viaggio di circumnavigazione della Vettor Pisani, 89, 90 1886

[5] Nuove alghe del viaggio di circumnavigazione della "Vettor Pisani " Mem Reale Accad d Lincei IVa **6** 53 1889

lection of 229 numbers of Philippine algae, collected by himself, Dr. W. R. Shaw, and others. After studying and reporting upon a part of this collection, the writer, then engaged in a study of the marine algae of the West Indies and Peru, asked permission to turn the col-

CHAETOMORPHA KELLERSII M A HOWE, sp nov (Type specimen; natural size)

lection over to Mr F S. Collins, who was then working on the algae of the Philippines as represented in collections made by naturalists of the United States Fish Commission attached to the S. S. *Albatross*.

Later, Dr. Merrill sent approximately 300 specimens directly to Mr. Collins. Mr. Collins, at his death in 1920, left a manuscript on the Philippine algae that was nearly ready for publication, and this came into the possession of The New York Botanical Garden with Dr. N. L. Britton's purchase of the Collins algal herbarium in 1922 and his donation of it to the Garden. In October, 1928, this Philippine manuscript was turned over to Professor William Albert Setchell of the University of California, who with a Mr. Manza, a Filipino student, was then preparing to make a special study of the marine algae of the Philippine Islands. The following list of 21 species from Panay and Negros islands is to be looked upon as a modest contribution to the more extended treatise that is to be expected from the University of California.

I ALGAE COLLECTED ON PANAY ISLAND, PHILIPPINE ISLANDS, BY LIEUT H. C. KELLERS, 1929

CHLOROPHYCEAE

ENTEROMORPHA LINGULATA J. Ag

Chaetomorpha Kellersii M A Howe, sp nov FIGURE 1.

Filamentis longis fuscis liberis plus minusve tortis et intricatis, 200–450μ crassis, ad septa vulgo leviter constrictis, allantoideis, cellulis diametro 2–4 (–7)-plo longioribus, brevi-cylindricis aut subclavatis, saepe irregulariter constrictis vel subtortis, in siccitate saepe valde, interdum alternatim, collabentibus, parietibus modice tenuibus, maximam partem 3–18μ crassis

A *Ch Lino* (O F Muell) Kuetz in filamentis crassioribus fuscis, cellulis longioribus polymorphis plus collabentibus, a *Ch torta* (Farl) Yendo filamentis tenuioribus fuscis, cellulis longioribus polymorphis, etc , differt

CAULERPA CLAVIFERA (Turn) Ag

CAULERPA MACRODISCA Decaisne

ACETABULARIA MAJOR Martens

PHAEOPHYCEAE

TURBINARIA CONOIDES (J Ag) Kutz

PADINA DISTROMATICA Hauck

RHODOPHYCEAE

GALAXAURA FASTIGIATA Decaisne

GELIDIUM RIGIDUM (Vahl) Grev

EUCHEUMA MURICATUM (S G Gmel) Web -v Bosse

GRACILARIA COMPRESSA (Ag) Grev.

GRACILARIA LICHENOIDES (L) Grev

ACANTHOPHORA ORIENTALIS J. Ag

LITHOPHYLLUM sp., on *Gelidium rigidum*

II. ALGAE COLLECTED ON NEGROS ISLAND (OCCIDENTAL), PHILIPPINE ISLANDS, BY LIEUT. H. C. KELLERS, APR. 20, 1929.

PHAEOPHYCEAE

SARGASSUM POLYCYSTUM Ag , var.
SARGASSUM SILIQUOSUM J. Ag.
DICTYOTA DICHOTOMA (Huds.) Lamour
PADINA AUSTRALIS Hauck

RHODOPHYCEAE

HYPNEA MUSCIFORMIS (Wulf) Lamour
ACANTHOPHORA ORIENTALIS J Ag
SPYRIDIA FILAMENTOSA (Wulf.) Harv.
AMPHIROA FRAGILISSIMA (L) Lamour.

III ALGAE COLLECTED ON NIUAFOOU ISLAND, BY LIEUT H C. KELLERS, AUGUST-OCTOBER, 1930

Niuafoou[6] Island is a partly submerged volcanic crater in the Pacific Ocean in latitude 15° 33′ 55″ S and longitude 175° 37′ 46″ W , and lying between Samoa and Fiji "Good Hope Island" appears as a synonym on some of the maps The name given to it by the discoverer, Captain Edwards, in 1791, is said to have been "Proby Island " It has also been nicknamed "Tin-can Island," from the method of delivering the infrequent mail by throwing it overboard in a sealed can from the visiting steamer So far as is known to the writer, no algae have been previously reported from this island

MYXOPHYCEAE

LYNGBYA MAJUSCULA (Dillw) Harv

CHLOROPHYCEAE

SIPHONOCLADUS INFESTANS Setch
VALONIA AEGAGROPILA Ag. Sept 14 and Oct 12, 1930
VALONIA FASTIGIATA Harv Sept 11 and 17, and Oct 1 and 12

PHAEOPHYCEAE

ECTOCARPUS sp , near *E Mitchellae* Harv., on *Laurencia flexilis*
SARGASSUM ANAPENSE Setch. & Gard. Sept 29 and Oct 1
SARGASSUM CRISTAEFOLIUM Ag Oct 1, 2, and 4.
TURBINARIA ORNATA (Turn) J. Ag.

RHODOPHYCEAE

ACTINOTRICHIA RIGIDA (Lamour.) Decaisne
LAURENCIA FLEXILIS Setch Aug 26, Sept 17, Oct 1 and 16
JANIA CAPILLACEA Harv.
AMPHIROA FRAGILISSIMA (L) Lamour

[6] Sometimes spelled Niuafoo, Niuafou, and Niuafu.

PALEOBOTANY.—*A new Oak* (Quercus perplexa) *from the Miocene of the western United States.*[1] EDWARD W. BERRY, Johns Hopkins University.

In 1902 Knowlton described the basal part of a leaf from the Mascall beds at Van Horn's ranch in the John Day basin (Grant County), Oregon, which, because it had an inequilateral base, he mistook for a leaflet of a compound leaf and named *Sapindus oregonianus.*[2]

Only this single type specimen was collected and no other specimens have ever been referred to in print. Some years ago Messrs. C. P. Ross and J. Heupgen collected a second specimen from the northwest corner of Section 19, Township 7 South, Range 46 East, near Richland, Baker County, Oregon (U. S. Geol Survey Locality 7515). The latter came from light colored diatomaceous beds interbedded with Columbia lavas. It was submitted to the late Dr. Knowlton who identified it as *Sapindus oregonianus*. It is undoubtedly identical with the Mascall leaf to which that name was given, and shows three complete leaves, which I suppose Knowlton mistook for leaflets

A glance at the accompanying illustration shows at once that this is not so, but that the specimen shows the distal portion of a very thick twig, and that the leaves are alternate in habit. This eliminates the genus *Sapindus* from further consideration although the venation is not very different from that of a number of forms from the western Miocene which have been referred to that genus.

The next question to decide is what genus these leaves do represent, and this is not an easy decision. I first looked through the associated Mascall species. Among these the only form at all similar to what was called *Sapindus oregonianus* is one Knowlton called *Salix perplexa.*[3] This is very similar in both form and venation, but tends to be somewhat smaller, more narrowly cuneate at the base, and more nearly equilateral, although the small leaf shown in Knowlton's figure 7 is quite inequilateral. Incidentally his figure 8 belongs to an entirely different species. It may be noted that one of the leaves of the present figured specimen is decidedly inequilateral, one is much less so, and the third is not at all inequilateral, thus showing that this feature is of no significance.

Knowlton compared his *Salix perplexa* with the existing *Salix bebbiana* of the northern Rocky Mountain region and elsewhere, but I can not see any such resemblance. The latter is frequently serrate,

[1] Received Feburary 8, 1932

[2] F H KNOWLTON U S Geol Survey Bull **204** 79, p 15, fig 3 1902

[3] F H KNOWLTON U S Geol Survey Bull **204** 31, p 2, figs 5–8 1902

the secondaries are fewer and more ascending, and the twigs are pubescent or puberulent. Moreover it has conspicuous stipules, of which there are no traces in Knowlton's figure 5, or in the excellent specimen which is the subject of this note. The latter should certainly show traces of the stipules if they had ever been present, particularly as it is a terminal twig

I am inclined to think that *Sapindus oregonianus* and *Salix perplexa* represent the same botanical Miocene species, but that it is not a *Salix*. It can not be a *Sapindus* because of the habit, and although the venation does not preclude such an identification it seems to me to be more like that in many entire leaves of the genus *Quercus*, although in the latter the secondaries are apt to be more widely spaced.

Figure 1 *Quercus perplexa* (Knowlton) Berry

It seems ridiculous to describe a new oak from this region and horizon when one holds the often expressed conviction that there are already far more nominal species of *Quercus* than there were botanical species, and yet, in dealing with no other parts of the plants than leaves, I know of no other course, and it is justifiable if it is kept clearly in mind that all that is being done is recognizing a certain leaf-form which may have belonged to a botanical species with dimorphic or polymorphic foliage, like so many existing species in the west, southwest, and in Mexico.

The last mentioned region at the present time also affords justification for the assumption that, with the progressive aridity in parts of the west during the later Tertiary, new species came into existence,

many of which may have been the ancestors of the existing species of the Mexican plateau and of the Sierra Madre mountains which border it. Certainly a considerable number of species of Miocene *Quercus* have foliage closely comparable with existing Mexican species, and this has been pointed out in connection with the printed discussion of some of them.[4]

The new species, assuming that it comprises both what has been called *Salix perplexa* Knowlton and *Sapindus oregonianus* Knowlton, takes the specific name of the first of these, which not only has priority of position, but is fortified by the fact that the name *oregoniana* has already been used for a different species in the genus *Quercus*. The new species is therefore called *Quercus perplexa*, and may be redescribed as follows.

Quercus perplexa (Knowlton) Berry

Fig 1.

Leaves of variable size, ranging from 2 25 to 5 5 centimeters in length, and from 1 2 to 2.5 centimeters in maximum width Outline elliptical-lanceolate to ovate Base cuneate, abruptly narrowed to the petiole, and frequently inequilateral Apex usually cuspidate Margins entire, more or less revolute This is well shown on the right side of the largest and the left side of the smallest leaf here figured. Texture coriaceous Petiole short and very thick, not over 5 millimeters in length Midvein very stout and prominent proximad, conspicuously less so distad Secondaries about 12 pairs, subparallel, rather straight, sometimes one of the secondaries will be dichotomous from near the base, they all diverge from the midvein at wide angles and are abruptly camptodrome well within the margins Tertiaries camptodrome in the marginal regions, forming open polygonal meshes between the secondaries

I have not seen any modern species in which all of the leaves are exactly like the fossil, but there are a considerable number of modern species with polymorphic leaves in which occasional leaves are very similar or identical with what I have called *Quercus perplexa* I mention a number of these below, but do not think that they have anything more than a generic significance For the most part all show considerable variation and tend to have entire leaves on old trees, and variously toothed margins on young trees or shoots—environments being apparently the guiding influence. I refer to species such as *wislizeni* DeCandolle, *oblongifolia* Torrey, *emoryi* Torrey, *arizonica* Sargent, *chrysolepis* Liebman, and *engelmanni* Greene Doubtless other existing species from farther south could be enumerated

It seems to me that, from the features shown and the considerations just mentioned, the present redetermination is abundantly justified

[4] See for example the discussions of *Quercus mccanni*, *Quercus simulata*, and *Quercus treleasii* in U S Geol Survey Prof Paper 170 36–37. 1931.

ETHNOBOTANY—*Mexican folk remedies of Chihuahua.*[1] ROBERT M. ZINGG, Department of Anthropology, University of Chicago. (Communicated by PAUL C. STANDLEY.)

This paper deals with the remedies used by the Mexicans of the lower and lower middle classes of the State of Chihuahua, in clear distinction from the primitive Tarahumara Indians, who furnish a few and the most important of them. While engaged in a study of the material culture of the Tarahumaras of the southern part of the State of Chihuahua, the writer had occasion to observe the prominent place in that culture occupied by medicinal plants, which will be described in another publication. These Indians collect several plants of such general esteem by their Mexican neighbors as to be worth the long foot-trip down from the distant Sierra to the capital city of Chihuahua, a distance of a hundred and twenty miles.

In general, it is quite apparent from the business of the *boticas*, that Mexicans are great believers in medicines, and none of them would be satisfied with a doctor's visit if he did not prescribe at least a half dozen different medicines, none of which does any harm. And so among the lower classes who can not afford the luxury of medical men and mixtures from the *botica*, a great profusion of medicinal herbs are relied upon, the virtue of which is largely that they, also, do not harm.

These data are not submitted as a contribution to medical knowledge, but they do involve more than mere curiosities in human behavior. Many of these medicinal plants show a far-reaching diffusion of technique in preparation for the identical ailment, rather than local and chance beliefs. *Jatropha* as a remedy for scratched eyes was carried by the Spaniards to the Philippines, where it gained the identical folk use.

The lore attaching to plants forms an important aspect of primitive and folk cultures which has not had adequate treatment by students of human culture. As Dr. Laufer says "Cultivated plants are an essential element in the history of human ecology and civilization, and their study must be grasped in the sense of a cultural movement."

This paper is submitted in the thought that, though a meagre catalog of remedial plants, it is a slight addition to our knowledge; which, like Redfield's *Remedial Plants of Tepoztlan*, will eventually build up a literature very valuable to the ethnobotanist who attacks the great problem of plants in Mexican culture.

[1] Received February 29, 1932

Nothing could be more simple than gathering the material for such contributions. The present writer spent three hours in the special booth for medicinal plants in the public market of the city of Chihuahua, buying the different plants and noting on the envelopes containing them the local names and the uses, as well as the locality and the method of growing the plants.

For the value and coherence of this material, the reader is indebted to Mr. Paul C. Standley, of Field Museum of Natural History, who was generous enough of his wide knowledge of Mexican plants to identify and arrange these species, for which assistance the writer is deeply indebted

Two wide-spread Mexican folk beliefs about animals may be mentioned. Injuries to the head, and headache, are thought to be caused by entrance of air through the ears. The bright feathers of the rare and magnificent giant woodpecker (*Campephilis imperialis*) are thought to be especially valuable as ear-muffs to prevent this Consequently the Mexicans have practically exterminated this splendid bird in the Sierra Tarahumara. The well-known Tiger Salamander (*Ambystoma tigrinum*), which the Mexicans universally call by its Aztec name *axolote*, is common in the Sierra. Tarahumara in its larval form. In color it is spotted black and yellow, and is aquatic and has gills. The larval form is able to reproduce for generations and remains aquatic, though if the water disappears it becomes adult and terrestial. This ugly, though of course harmless, animal is the object of a widespread belief among the Mexicans, which the writer encountered in Chihuahua and New Mexico. It is thought to be especially dangerous to women, who are careful about nearing rivers, and would never sleep near them for fear of the animal entering their bodies.

There is a very widespread belief in Mexico about a fictitious plant which they call "quiebra muelas,"—molar-breakers. The belief was noted in Chihuahua. These plants are supposed to be very corrosive, and therefore dangerous to carry on the person. Ground up and placed on an aching tooth or the gums adjacent, they cause the tooth to be broken up and fall out.

POLYPODIACEAE

1. NOTHOLAENA SINUATA (Sw.) Kaulf.

Calahua del indio. Name is usually *calaguala* This fern is esteemed as an excellent remedy. The decoction is drunk as a treatment of inflammation and bruises

SELAGINELLACEAE

2. SELAGINELLA SP
Flor de peña. This "resurrection plant" is brought by the Tarahumaras from the Sierra Madre to be sold to the Mexicans, by whom it is appreciated as a remedy for colic and indigestion.

EQUISETACEAE

3. EQUISETUM HIEMALE L
Cola de caballo (Horse's tail) This horsetail or scouring rush is planted by the Mexicans in gardens near running water. Its decoction is drunk without sugar as a remedy for pains in the kidneys.

LILIACEAE

4. YUCCA SP.
Flor de palma. The flowers of the yucca plant are dried and brought considerable distances to Chihuahua, where they are sold. Their decoction is drunk as a remedy for colds

AMARYLLIDACEAE

5. AGAVE SP
Amole The thickened roots of small agaves are collected by the Tarahumaras and brought down to the city of Chihuahua, for sale in the herb market. They are used like soap for washing clothes.

SAURURACEAE

6 ANEMOPSIS CALIFORNICA H & A
Hoja de babisa. This plant is grown in Mexican gardens along running water. The leaves and fleshy roots are boiled and the decoction used as a wash for sores and boils It is the *yerba mansa* of southern California.

JUGLANDACEAE

7 JUGLANS MAJOR (Torr) Heller
Nogal From walnut leaves is prepared a beverage that is drunk like tea with sugar.

POLYGONACEAE

8. ERIOGONUM TENELLUM Torr
Chuchara Mexicans bring this plant from the mountains to Chihuahua, where it is sold as a remedy The plant is boiled and its decoction drunk as a purgative.

AMARANTHACEAE

9 AMARANTHUS PANICULATUS L
Quelite morado The decoction is drunk by pregnant women as a remedy against morning sickness.

LAURACEAE

10. LITSEA GLAUCESCENS H. B K.
Laurel The leaves of this laurel tree are very fragrant, and when boiled make a very tasty and refreshing tea, with sugar The Tarahumaras, who appreciate it only as a medicine, especially since they do not have sugar, harvest considerable quantities of the leaves and bring them to Chihuahua, where they bring a good price.

The Mexicans not only appreciate laurel as a tea, for which they use it more commonly than the more expensive and less fragrant Asiatic teas, but they also attribute to laurel medicinal properties They say that the decoction, drunk with sugar, is a remedy helpful for gas in the stomach.

ROSACEAE

11. Prunus capuli Cav.

Corteza de capulín. The wild cherry is a mountain tree, brought from the Sierra Madre by the Mexicans for sale Its bark is boiled and the decoction drunk as a tea, without sugar, in the treatment of colds

LEGUMINOSAE

12. Prosopis chilensis (Mol.) Stuntz

Corteza de mezquite. The decoction of mesquite bark is drunk as a purgative and to clarify the urine

13. Zornia diphylla (L) Pers

Hierba de víbora (Rattlesnake weed) This is esteemed by the Mexicans for colds and fevers The decoction is drunk by children, though often adults mix it with their liquor *(sotol)*

ZYGOPHYLLACEAE

14. Larrea tridentata (DC) Coville

Wame gobernadora The characteristic "creosote bush" of the Chihuahuan desert The branches are picked from the fields, and saved for their medicinal uses. They are fried with lard and used hot as a poultice in the treatment of rheumatism

RUTACEAE

15. Citrus limonia Osbeck

Limón. Lemon peel is ground with the seed of the avocado *(Persea americana* Mill) and used warm as a poultice

Orange peel is burned in charcoal braziers as a preventive of headache.

16 Ruta chalepensis L

Ruda Grown in Mexican gardens for the use of its decoction for "air in the intestines and stomach " Rue is a European plant

Ruta graveolens "Its odor is very strong, its taste sharp and bitter Contains a glucoside, rutine, and an essential oil to which it owes its physiological properties. It exercises locally an irritating action on the skin and mucous membrane. Used internally it can cause gastro-enteritic accidents with spasms and convulsions It is employed as a stimulant to uterine contractions and against hemorrhages Only indirectly it produces abortions " *(Farmacopea Latino-Americana,* p 565)

EUPHORBIACEAE

17. Croton monanthogynus Michx

Encinilla This low herb of the spurge family is cultivated in Mexican gardens, or the plants are gathered on the plains It is boiled and "drunk with sugar as a cordial, when one cannot drink coffee "

18. Euphorbia sp.

Hierba de la golondrina A prostrate herb, gathered from the fields and used by the Mexicans in treatments of boils and ulcers The decoction is used as a wash; and then part of the dry leaves are ground up and dusted on

the cleaned lesion on the skin Throughout Mexico and the southwestern United States similar spurges have high repute as a remedy for rattlesnake bites.

MALVACEAE

19 MALVA PARVIFLORA L

Malva This mallow is commonly planted in gardens by Mexicans, or bought, its decoction being appreciated by women as a douche.

LOGANIACEAE

20. BUDDLEIA SCORDIOIDES H. B K

Escobilla. A pale, woolly shrub with flowers in spherical heads The decoction is drunk as a purgative

APOCYNACEAE

21 MACROSIPHONIA HYPOLEUCA (Benth) Muell

Rosa de San Pedro. The Mexicans bring this plant from the mountains. It is a small shrub with beautiful, large, white flowers Its decoction is esteemed for bathing infected eyes.

CONVOLVULACEAE

22 DICHONDRA ARGENTEA Willd

Orejuela de ratón (Mouse's ear) The plant is a diminutive creeping herb with silvery, kidney-shaped leaves The decoction is drunk as a remedy for jaundice It is thought also an excellent remedy for "frights," to which are attributed many ills among the Mexican folk as well as the Indians

HYDROPHYLLACEAE

23. NAMA UNDULATUM H B. K

Ventosidad This plant is grown in Mexican gardens for sale as a folk remedy Its decoction is drunk for the common digestive disorder of gas on the stomach Of its efficacy the herb vender told me that when so taken, "then the balloon on the inside goes down" The Mexican name for the plant, *ventosidad*, means "windiness" or "gas on the stomach"

VERBENACEAE

24 LIPPIA BERLANDIERI Schauer

Orégano The dry leaves of this aromatic shrub are pulverized and sprinkled on food as a seasoning The decoction is drunk as a remedy for colds

LABIATAE

25 MENTHA SPICATA L. (Spearmint)

Hierbabuena The plant is commonly grown in gardens. The decoction is drunk for indigestion

"It has stimulating properties, it is an antispasmodic, being generally administered as an infusion It is much used in folk medicine in this way." (*Farmacopea Latino-Americana*, p 393).

SOLANACEAE

26. SOLANUM ELAEAGNIFOLIUM Cav.

Trompillo A field weed The berries are used to curdle milk after boiling, in the Mexican cheese-making technique The plant bears the same name in New Mexico and western Texas, where it is employed for the same purpose.

PLANTAGINACEAE

27. PLANTAGO MAJOR L.

Semilla de llantén. Masorcita de llantén. The seeds of plantain are planted in Mexican gardens because of the medicinal use of the plant, which is commonly boiled and its decoction drunk as a remedy for dysentery or diarrhea

"*Semilla de llantén. Mazorquita de llantén.* The greater part of these contain in their seeds inverted sugar emulsion, also a glucoside that can be crystallized, identical with the aucubine of *Aucuba japonica* The whole plant is used as an astringent, and its juice is employed in folk medicine as a febrifuge, and against the bites of rattlesnakes (?!). It does not give results." (*Farmacopea Latino-Americana*, p 432)

COMPOSITAE

28 CHRYSACTINIA MEXICANA Gray

Damiana Hierba de San Nicolás The Mexican women esteem this small aromatic shrub, which they boil and drink as a tea in the belief that it is helpful during pregnancy

"Various extracts from this plant have been given to animals, and result non-tonic and have no physical action(!) The decoction and tincture of the plant have been applied to see if the plant had any tonic effects The results so far have been nil, but the number of experiments to date has not been sufficient to prove whether or not it exercises any tonic action." (*Farmacopea Latino-Americana*, p 454)

29 ARTEMISIA MEXICANA Willd

Istafiate This is a common Mexican herb remedy, the decoction being drunk by children for colic Adults sometimes drink it in liquor. The plant has a bitter flavor

"It is used in Mexico as a substitute for true *ajenjo* (*Artemisia Absinthium*; from which absinthe is made) since it has very similar properties It contains an essence and santonine, the latter in the inflorescences to 1 24%

"The tincture does not produce any action local or general, and is not a tonic. It retards the action of the gastric juice, and slows up digestion

"Its essence paralyzes the movements of the frog, leaving its sensibility intact, however It appears less poisonous than the essence obtained from *Artemisia Absinthium* The plant may be employed as an anthelmintic, and to modify sensibility There is a common folk belief that it works as a stomachic In some cases it appears to operate as a light aperitive " (*Farmacopea Latino-Amerciana*, pp 306–7)

30 BRICKELLIA SP

Pestón Gathered from the fields and saved to boil, the decoction being used as a purgative

31 CIRSIUM UNDULATUM (Nutt) Spreng

Cardo santo The decoction of this native thistle is used for bathing swellings

32 DYSSODIA ACEROSA DC.

Hierba del arriero This is an aromatic field weed which is dried, and its decoction drunk as a purgative

33 FLOURENSIA CERNUA DC.

Hojasén. This plant is a resinous shrub, that is gathered from the fields, and a small amount of the decoction drunk as a purgative It is so strong in action that only a little is taken

34 GNAPHALIUM WRIGHTII Gray

Manzanilla del río. This is a woolly herb from the Sierra Madre which is brought to Chihuahua by the Mexicans. It finds a sale, since they think its decoction good for colds. It may also be used as a wash for sores and ulcers.

35. MATRICARIA COURRANTIANA DC.

Manzanilla de Castilla This small white daisy is a favorite plant in Mexican gardens, its decoction being used as a hot douche.

M. Chamomilla L (Compositae) "In the markets the heads are found for sale, with more than 5% of the stalks and foreign substances . . The odor of the plant is aromatic and agreeable, its taste aromatic and sour. Contains a volatile acid dark blue in color which is soluble in alcohol. It is a tonic and stimulant to a dose of 16 grains In large quantity it is an emetic." (*Farmacopea Latino-Americana*, p 348)

36 TAGETES ERECTA L.

Flor de muerto Sempual The garden marigold is grown in Mexican gardens for use and sale as a medicine, as well as for ornament. Its decoction is thought to be an excellent remedy for diarrhea.

37 TAGETES LUCIDA Cav.

Hierba anís The decoction of this strong-scented plant is drunk for colic and wind on the stomach It is often taken with honey

"This is one of the most widely used medicinal plants of western Mexico. The species has a wide distribution The plants gathered by the country people are made up in small bundles and dried, and then put away for use. It is made into a tea, and supposed to have numerous virtues, including efficacy against scorpion bites, fever, ague, etc

"Dr. Palmer says that in Colima it is made into an insect powder This is the same plant as the Santa María of the Cora Indians." (Rose: Notes on the Useful Plants of Mexico, p 231)

38 TAGETES MICRANTHA Cav

Anisillo. A small, weedy, strong-scented herb, whose decoction is drunk for stomach trouble

39 ZINNIA GRANDIFLORA Nutt

Cinco llagas. A weed picked from the fields, a relative of the garden zinnia. Its decoction is drunk as an astringent for diarrhea.

40. CACALIA DECOMPOSITA Gray

Matarique (Mex), *pi-tcá-wi* (Tar) This is one of the most esteemed medicinal plants furnished by the Tarahumara Indians of the barrancas to the Mexicans of Chihuahua There they consider it a cure for diabetes, and pay the Indians a good price for it The plant is listed in the *Farmacopea Latino-Americana*, which supplies these data:

"It is a plant of a meter in height, flowers in September and October The root is aromatic and presents, upon breaking, an abundant zone of yellow resin It comes from the mountains of Santa Cruz (Sonora), and Mapula (Chihuahua)

"The root is employed, since it contains two resins, essential oil, glucoside, tannic acid, and grease. The hydro-alcoholic preparation of the root acts to paralyze the motor system of the striated muscles, and the heart; it produces a light anaesthesia by its local peripheral action.

"The tincture favors scarification of the tissues when applied on ulcers, wounds, etc , by its antiseptic action owing to a coating that it forms.

"Given internally, it produces emetic and cathartic effects, and general retardation, but on occasions its use has caused chloroform accidents of a grave nature.

"Rheumatic pains, especially of the joints, as well as neuralgic pains are calmed by its application in *loco dolente*. The rapid scarification of ulcers and wounds is favored by washing them with a mixture of the tincture in water, or by the tincture alone

"In the hospital of San Andrés they used the same tincture as a purgative, but the results were variable, with two doses up to 100 grams chloroformic accidents occurred involving the heart. With two doses of 30 grams no purgative effects were obtained, and its use only succeeded in calming indigestion and headache

"The ordinary preparation is the tincture of the root (one part of the root to five of alcohol or an 80% solution). It is administered internally in doses of 30–100 grams with variable effects Externally it is applied as a sedative of pain by rubbing the *locum dolentem* As a vulnerary it is mixed with equal parts of water"

This plant, after being pounded and boiled for fifteen minutes, is used by the Tarahumaras as an internal remedy for colds Its properties as a vulnerary are understood by them, as they wash wounds in its decoction Its paralytic effects on the central nervous system are utilized by the Tarahumaras, whom I saw using it as a fish poison, in water retained by damming

The purgative property of the plant is also known to the Tarahumaras A bundle of the roots that can be encircled by the thumb and finger is ground on the metate. This is drunk with plenty of warm water The Indians say that it is a very drastic purgative, and that its action must be stopped by eating cold *atole* (corn mush).

ZOOLOGY.—*A new Pinnotherid crab from the Hawaiian Islands.*[1]

MARY J. RATHBUN, United States National Museum.

Dr. Charles H. Edmondson of the Bernice P. Bishop Museum has submitted for report a new form of the curious genus *Aphanodactylus* described by Tesch.[2]

Aphanodactylus edmondsoni, new species

Compared to *A. sibogae* Tesch, carapace narrower, 9 6 x 16 2 mm, as against 6 x 11 25. Fronto-orbital distance greater, 7 6 mm, or more than 4/10 of carapace width of *sibogae* Posterior width 8 6 mm, instead of 1-1/2 x fronto-orbital distance Antennal flagellum not 2 or 3-jointed, but 10-jointed, terminating in a slender seta Palp of maxilliped long, overreaching a little the merus-ischium suture Merus-ischium narrower than in *sibogae*; inner margin of merus nearly straight instead of convex Merus of ambulatory legs 1–3 armed below with a large triangular spine-tipped tooth at distal third; the tooth of third right leg only is bispinose at tip, apparently an abnormality Merus of last leg has two very small spines on posterior margin. Carpus of ambulatory legs tapering distally (not narrowed in female of *A. sibogae*). Carpus-propodus hairy on both margins, merus hairy below.

[1] Published with the permission of the Secretary of the Smithsonian Institution Received February 19, 1932

[2] Decapoda Brachyura Siboga Exped, Mono XXXIX c[1], 1918, p 283, pl 18, fig 2.

Fine hair borders arm, inner angle of wrist, prehensile margins of fingers; a small patch at middle of inner surface of palm; long hair on lower margin of carapace, margin of abdomen and surface of maxilliped; a row of short thin hair above edge of rostrum

Type-locality —Oahu, from worm tube, Nov. 27, 1931 Holotype in Bishop Museum.

ZOOLOGY.—*A new species of* Cyclops *from the Philippine Islands.*[1]

C. DWIGHT MARSH, United States National Museum.

The following description is of the mature female.

Cyclops philippinensis, new species

The first segment of the cephalothorax is considerably longer than the remaining part.

The abdomen, Fig 1, is about two-thirds as long as the cephalothorax The first segment about equals in length the three following, and its greatest breadth about equals its length. The second, third, and fourth segments gradually diminish in length, the fourth being about one-half as long as the second. The posterior borders of the abdominal segments are very finely dentate.

The branches of the furca about equal the combined length of the third and fourth segments The lateral setae are situated at about two-thirds the length of the furca Of the terminal setae, Fig. 3, the first and fourth are nearly equal in length, the fourth being slightly longer The third seta is longer than the second and is somewhat more than four times the length of the fourth

The segments of the abdomen and furca are covered with minute pellucid dots These dots are arranged in transverse lines on the first segment and sometimes on the other segments The dots are not projections from the surface, and so far as the author knows, are peculiar to this species.

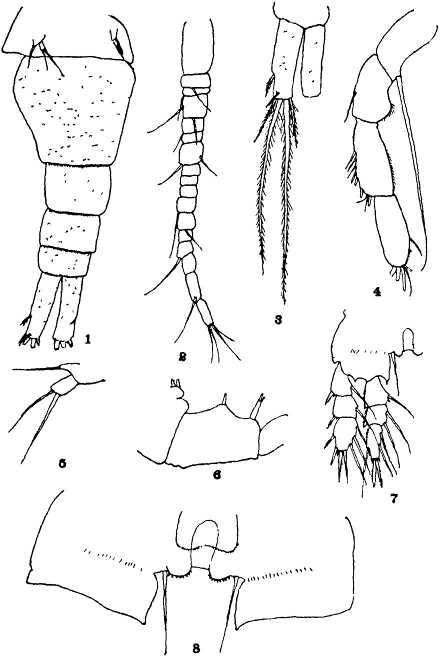
The first antennae, Fig 2, about equal in length the cephalothorax They have seventeen segments and there are no hyaline lamellae on the sixteenth and seventeenth segments In the second antennae, Fig 4, the third and fourth segments are about equal in length The lower border of the second segment of the posterior maxillipede has crenulations, Fig 5, resembling those found in *C leuckarti*

The spinous armature of the terminal segments of the exopods of the swimming feet is represented by the formula 2, 3, 3, 3 In the fourth feet, Fig. 7, the terminal spines of the third segment of the endopod are nearly equal in length

The membrane connecting the bases of the swimming feet has two rounded processes, each armed with a number of dentations, Figs 7 and 8. Such pro-

[1] Received February 9, 1932

Fig 1 *Cyclops philippinensis*· abdomen of female, x 223 Fig 2 *Cyclops philippinensis*: first antennae of female, x 223 Fig 3 *Cyclops philippinensis*: furca and furcal setae of female, x 223 Fig 4 *Cyclops philippinensis*: second antenna, x 438 Fig 5 *Cyclops philippinensis* fifth foot, x 438 Fig 6 *Cyclops philippinensis* second segment of posterior maxillipede, x 438 Fig 7 *Cyclops philippinensis*: fourth foot, x 223 Fig 8 *Cyclops philippinensis*: connecting membrane of fourth feet, x 438



Figs 1–8. *Cyclops philippinensis* For explanation see page 182

jections were reported by Schmeil,[2] 1892, as found in the fourth feet of *C. oithonoides*, but not on feet 1 to 3. He also stated that the processes were found in *C hyalina* and *C dybowskii* on all the swimming feet, but that the processes were more of a semicircular form in these species It is evident that the processes in *C philippinensis* correspond more closely to those in *C. hyalina* and *C. dybowskii*, for they are distinctly semi-circular in outline. Sars,[3] 1918, figures similar projections for the fourth feet of *C. crassus*.

The fifth foot, Fig 5, is two segmented The second segment is twice as long as broad the setae are terminal and the inner seta is longer and stouter than the outer. The form of the *receptaculum seminis* could not be clearly distinguished in the available material.

Length: From 0 9 to 1 0 mm.

This was received from Dr Stillman Wright and was collected by P. B. Sivikis, at Manila, Philippine Islands

This form evidently belongs to genus *Mesocyclops* Kiefer, and subgenus *Thermocyclops* Kiefer. It is most nearly related to *C. oithonoides* Sars The lack of hyaline membranes on the terminal segments of the first antennae, the armature of the membrane connecting the bases of the swimming feet, the form and armature of the fifth feet, and the markings of the abdomen separate this from any described species.

[2] Schmeil, 1892, *Deutschlands freilebende Süsswasser-Copepoden-Cyclopidae*. Bibliotheca Zoologica, Vol 6

[3] Sars, G O, 1918 *An account of the Crustacea of Norway* Vol. VI, Copepoda, Cyclopoida

ZOOLOGY.—*Notes on* Talorchestia fritzi *Stebbing*.[1] CLARENCE R. SHOEMAKER, U. S. National Museum. (Communicated by W. L. SCHMITT.)

Among some crustacea recently received by the United States National Museum from Professor Manuel Valerio of San José, Costa Rica, were six amphipods of the genus *Talorchestia*, taken on the Pacific coast of Costa Rica. One of the males is undoubtedly *Talorchestia fritzi* described by Mr. T. R. R Stebbing[2] in 1903 from Isla del Coco, off the Pacific coast of Costa Rica. The two remaining males are somewhat larger and show marked differences in some characters from *T. fritzi*, but in most they agree completely with it. The greatest difference appears in the form of the sixth and seventh joints of the second gnathopods of the male. Fritz Muller[3] has pointed out the differences in form which take place in some of the characters of sexually mature males of *Orchestia tucuraùna*. The alteration in the form of the sixth joint of the second gnathopods and the fusion of the first

[1] Published by permission of the Secretary of the Smithsonian Institution. Received January 29, 1932

[2] Stebbing, 1903, Proc U S Nat Mus, vol XXVI, p 925, pl 60

[3] Fritz Müller, *Facts and Arguments for Darwin*, London, 1869, pp 79–80.

few joints of the flagellum of the second antennae are among the principal changes which he noted. In *O. tucurauna* the young mature males had an evenly convex palm which, as the animal became older, acquired a deep emargination near the hinge of the seventh joint, and the seventh joint developed a corresponding prominence which exactly fitted into the emargination when the joint was closed against the palm. In the youngest mature males the joints of the second antennae were all free, but as maturity advanced the first few joints became fused.

I have examined the specimen of *Talorchestia fritzi* which Mr. Stebbing studied and I find that the young males have the emargination of the palm and the protuberance on the seventh joint so slight as to be scarcely noticeable, thus approaching the condition of uniform convexity described by Muller. I have already stated that one of the males received from Professor Valerio agrees quite well with the description and figures of *T. fritzi* given by Mr Stebbing, except that the second joint of the second antennae is much more prominent and the fourth and fifth joints are much more massive. The two remaining males differ from the preceding specimen and Mr. Stebbing's specimens as follows. The second joint of the peduncle of the second antennae is even more prominent and the fourth and fifth joints still more massive. The first seven or eight joints of the flagellum are fused. Mr. Stebbing states that none of the flagellum joints are fused, but as the specimens which he examined had apparently been dried before they were put into alcohol this point is rather uncertain, though to me the first three or four joints have the appearance of being fused. The sixth joint of the second gnathopods is proportionally the same, but the emargination has become enlarged until it occupies about half the palm, and the remaining half of the palm has been crowded together into a high evenly convex prominence having at its junction with the posterior margin of the sixth joint a groove for the reception of the extremity of the seventh joint. The protuberance on the inner margin of the seventh joint has entirely disappeared so that when the joint is closed against the palm a large opening is formed by the palmar emargination.

These differences, while apparently very marked, are only such as could readily be due to the larger size and greater age and maturity of the specimens. I believe, therefore, that these two larger males are merely more fully developed and matured specimens of *Talorchestia fritzi* Stebbing. In the Amphipoda development is frequently

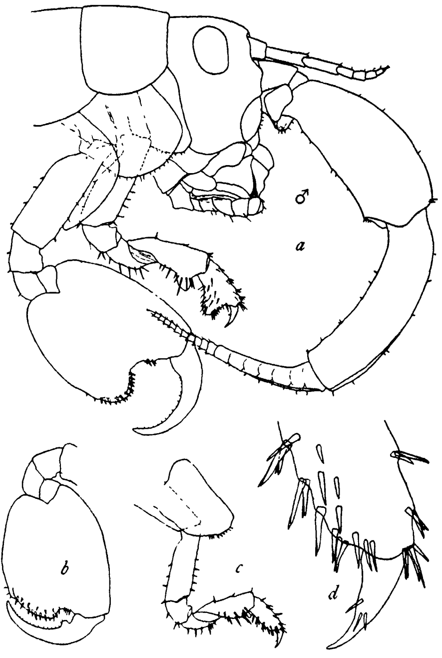


Fig 1 —*Talorchestia fritzi* Stebbing *a*, Head, antennae, and gnathopods of fully developed male *b*, Gnathopod 2, left, inside view of young male *c*, Gnathopod 1 of female *d*, Extremity of gnathopod 1 of female much enlarged.

accompanied by marked changes in the form of the second gnathopod of the male.

Although Mr. Stebbing noted the general resemblance in the second gnathopods of *T. fritzi* to those of *Orchestia tucurauna* he believed that there was enough difference in other characters to distinguish them as separate species. It is not possible to determine from Fritz Muller's description or figures whether his species is an *Orchestia* or a *Talorchestia*, so that with further knowledge of these two species they may well prove to be one and the same. The first gnathopods of the females of these specimens from Professor Valerio approach more decidedly a subchelate structure than is shown by Mr Stebbing in his figure. I have examined the females which he studied and find that the specimens show somewhat more of an approach to the subchelate structure than he has indicated. The dividing line between *Orchestia* and *Talorchestia* is so very hazy that at times it is difficult to decide into which of these two genera a species should be placed. For the present *T fritzi* had best be left in the genus *Talorchestia*.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BIOLOGICAL SOCIETY

765TH MEETING

The 765th meeting was held in the new assembly hall of the Cosmos Club 17 October 1931 at 8 10 p m, with President JACKSON in the chair and 33 persons present

FRANK THONE mentioned the observation of a partly albino robin recently near the National Academy building

E P. WALKER commented on Dr W M MANN'S return with specimens from British Guiana He also stated that both the lowland and mountain forms of gorilla are on exhibition at the Zoological Park

I. N HOFFMAN stated that Mr DENLY has raised this summer several rare species of pheasant, including Java peafowl and Elliot pheasant. He has about 25 species in captivity.

The regular program was as follows

WATSON DAVIS *Some recent biological expeditions*—The speaker has record of about 60 biological expeditions of greater or less importance afield throughout the world in 1931.

FRANK THONE *New books in biology*—The speaker exhibited and commented briefly on a considerable number of new books

S F. BLAKE, *Recording Secretary*

766TH MEETING

The 766th meeting was held in the new assembly hall of the Cosmos Club 31 October 1931 at 8 05 p m, with President JACKSON in the chair and 48 persons present. New member elected W. O. EMERY.

The following resolution was adopted:

Whereas, the Biological Society of Washington has learned with profound regret of the death of Dr J W GIDLEY, an ex-president of the society, and Assistant Curator of Fossil Mammals in the U S National Museum, therefore be it

Resolved, That this Society desires to place on record its sorrow at the loss of a valued member, and its appreciation of his ability as a scientist, and of his character and worth as a man

Resolved, further, that this resolution be spread upon the minutes of the society, and that a copy be transmitted by the Secretary to the bereaved family.

E P WALKER mentioned the new check list of birds recently issued by the American Ornithologists' Union.

The regular program was as follows

T. S. PALMER *The 49th Annual Meeting of the American Ornithologists' Union at Detroit, and the recent Audubon Society Meeting.*—JOSEPH GRINNELL was reelected president, A. C BENT and J. H FLEMING vice-presidents and W. L. MCATEE treasurer of the American Ornithologists' Union. Mrs FLORENCE MERRIAM BAILEY was awarded the Brewster medal of the Union for her recently published work "Birds of New Mexico" The next annual meeting of the Union is to be at Quebec in October, 1932.

LOUIS RADCLIFFE *A recent trip through the Upper Mississippi River Wild Life and Fish Refuge*—The speaker described a trip up the river from Dubuque, Iowa to Lake Pepin, Minnesota, with special mention of the effect of floods, the maintenance of a nine foot channel, and the fish rescue work of the Bureau of Fisheries

M. M. ELLIS *Biological aspects of the inland river situation (illustrated)*— The speaker outlined the destructive effect on aquatic life of river pollution through municipal and industrial waste and erosion silt. Acid products from industrial plants accumulate behind dams and even attack the metal parts of boats

E A GOLDMAN, *Recording Secretary, Pro Tem*

767TH MEETING

The 767th meeting was held in the new assembly hall of the Cosmos Club 14 November 1931, at 8.10 p m, with President JACKSON in the chair and 68 persons present

E. P. WALKER reported that several silver gulls are setting on eggs in the Zoological Park and that some nests hold downy young, showing a remarkably prolonged nesting season

FRANK THONE exhibited several recently published books, including Ditmars' "Snakes of the world," and Edgerton's "Elephant-lore of the Hindus"

The regular program was a *Symposium on the effects of drought upon plant and animal life*, with the following speakers.

M B WAITE: *Plants*—The drought of 1930 was the severest ever known in this vicinity. It produced little effect upon the early spring flowers, but its effects became evident in late spring and summer The steadiness of the drought resulted in little external injury such as leaf scald and tip burn. Annuals were more affected than perennials In 1930 very little sugar corn was raised in this region, most of it having to be cut for fodder owing to its poor development Melons and squashes did fairly well, as did forest trees and shrubs. The shallow-rooted flowering dogwood suffered most among native trees. The grass in meadows and pastures suffered severely and some of it was killed Peaches throve, apples suffered greatly, and pears were intermediate. There was a poor development of parasitic and fleshy

fungi. In 1931 there was a tremendous development of annual weeds. Tulips and other bulbous plants and iris did well in 1931, but gladiolus and lilies did poorly There was a great corn and tobacco crop in 1931. Peaches, oaks, and other trees were a couple of weeks late in ripening fruit and coloring their leaves in 1931, perhaps due to excess of nitrates in the soil resulting from continued lack of rain

C. R. LUCAS: *Fish.*—Many game fish, particularly trout, bass, and catfish, suffered severely from the heating of waters and abnormal sewage conditions due to drought Losses were most severe in the central and southern Mississippi River region and in West Virginia A great deal of work in salvaging fish from drying waters was carried on by the Bureau of Fisheries. A great deal of restocking and replacement will be necessary

W. B. BELL: *Birds and mammals.*—Birds and mammals have greater adaptability and power of locomotion than some of the lower groups and tend to concentrate in places where water is available in times of drought. The smaller mammals vary their food to obtain more moisture in such a way as to do more damage than at other times. The number and size of litters are reduced. The effects of the drought on waterfowl in Canada depended greatly on topography In the southern parts of Alberta and Saskatchewan, rolling country with depressions containing water, great areas became perfectly dry and a tremendous amount of injury was done to young birds by these conditions, as well as by the fact that farmers carried cultivation into these drying areas and ruined them as breeding places for birds.

J. A HYSLOP· *Insects*—The effects of drought on insects must be distinguished carefully from those of other factors. Species favorably affected by drought carried over into 1931 in large numbers, those injured in 1930 have in some cases come back vigorously in 1931 The net result is that 1931 was a year of exceptional insect injury. Aphids, Oriental fruit moth, and Mexican bean beetle suffered in 1930 and were scarce in the spring of 1931 but increased rapidly in the fall. Chinch bug and leafhoppers increased greatly in both years, as did mosquitoes through the change of streams to puddles Grasshoppers did little damage in the spring of 1930, greater damage in the summer and fall, and very great damage in 1931 in the Great Plains and Great Basin Cutworms and army worms were worse in 1931

M K BRADY *Amphibians*—In general, amphibians breeding in temporary spring ditches or pools suffered greatly, in part through drying up before metamorphosis, in part due to greater injury done by birds and other enemies Species breeding in permanent waters came through much better. Among closely related forms the effects of the drought were sometimes very different Species belonging to the Coastal plain suffered most The late breeders suffered more in 1930 than in 1931 Swamp tree frog, leopard frog, green frog, bullfrog, Fowler's toad, newt, and marbled salamander were not greatly affected by the drought Spring peeper, American toad, pickerel frog, common tree frog, Jefferson and spotted salamanders suffered much The red-backed salamander was greatly reduced in numbers and the four-toed salamander was nearly exterminated.

Discussed by E A GOLDMAN, LOUIS RADCLIFFE, E P WALKER, I N. HOFFMAN, and W T SWINGLE. Mr GOLDMAN described the effects of drought as observed in Lower California and Texas, and stated that in his opinion a continuous drought might exterminate very local species. Mr. RADCLIFFE stated that on account of the concentration of fish life, predators could cause great damage Young fish suffered from drying up of the protective vegetation on borders of water. The influx of salt or brackish waters

frequently killed whole populations outright. Mr. HOFFMAN spoke of great mortality observed among white birch, dogwood, and hemlock in local parks.

768TH MEETING

The 768th meeting was held in the new assembly hall of the Cosmos Club 28 November 1931, at 8.10 p m., with President JACKSON in the chair and 110 persons present. New members elected E B CHAMBERLAIN, R. H. COLEMAN, J. K. DOUTT, and T H WHITCROFT

FRANK THONE exhibited several new books, including Bentley and Humphreys' "Snow crystals"

F C. LINCOLN stated that he had received a telephone communication relating to the presence of downy young in the nest of a Barn Owl in Ohio during the month

The regular program was as follows.

T. S PALMER *Meeting in honor of the anniversary of William Henry Flower (1831-1899)* —Flower was born in Stratford, England, and was from an early age interested in natural history He graduated in medicine, was invalided home from the Crimean War, and became Curator of the Museum of the Royal College of Surgeons and Hunterian Professor of Comparative Anatomy. He became Director of the British Museum of Natural History in 1884. He was very accurate and painstaking in his work and insisted on making knowledge accessible to the people He was the founder of the modern methods of museum exhibition

H. C. BRYANT *National parks as sanctuaries for wild life (illustrated)*.—The speaker showed plain and color slides of some of the more interesting animals and plants found in the national parks, and gave figures on the number of larger mammals There are about 12000 elk, over 13000 mountain sheep, 1700 black bear, 250 grizzly bear, 25000 mule deer, 2000 white-tail deer, and 3000 black-tail deer in western parks Difficulties in administration are due mainly to four causes (1) to migration of animals outside park limits after severe storms, and subsequent shooting, (2) the spread of disease from domestic to wild animals, an increasing problem; (3) the naturalization of plants, such as foxtail grass, and animals, such as the opossum in Sequoia National Park, which do harm to the native fauna and flora, (4) and to artificial feeding during the winter and at other times, which is of doubtful value to the herds and to the bears In conclusion, he showed a reel of animal life in Yellowstone Park

I N. HOFFMANN· *Natural features in Washington city parks (illustrated)* —The speaker mentioned a number of the more interesting trees found in Washington parks, and exhibited pictures of park scenery.

769TH MEETING

The 769th meeting was held in the New Assembly Hall of the Cosmos Club 12 December 1931 at 8.10 p m with President JACKSON in the chair and 62 persons present New members elected. CORABEL BIEN, R. W. HARNED

T S. PALMER mentioned that W. H. FLOWER, about whom he spoke at the last meeting, was elected a corresponding member of the Biological Society on 8 February 1884, six weeks before he took the office of Director of the British Museum

The regular program was as follows:

HERBERT FRIEDMAN. *Social weavers of South Africa (illustrated)* —The social weaver (*Philetairus socius*) inhabits the semi-arid plains country of

southern Africa. The members of a whole flock unite in building a community nest, each pair having a nest inside it on the under side, entered by a vertical hole In the region studied, it nests in Acacia trees, and farther west in aloes. A pigmy falcon sometimes nests in one of the holes, but appears to live on good terms with the weavers, and the author never found feathers of the weaver in the stomachs of the falcons Although the white settlers usually protect the nests, the natives try to destroy them by burning, because of their fear of certain snakes which are frequently found on the nests and sometimes drop down on passers-by The author described his experiences in bringing back to the American Museum of New York a complete nest of these birds The social weaver builds a larger nest in proportion to its size than any other bird in the world and inhabits it for years It sometimes reaches fifteen feet or more in diameter

HORACE RICHARDS: *Biological studies on the New Jersey coast (illustrated)*. —The speaker described his work in the study and collection of lower invertebrates off the New Jersey coast and Delaware Bay, illustrating it with slides of many of the animals observed —In discussion, T S PALMER pointed out that whaling was formerly an important industry in Delaware Bay and off the New Jersey coast, and that a blackfish had actually been caught many years ago in the Delaware River at Camden, although this record had been discredited by Dr True

S F. BLAKE, *Recording Secretary*

SCIENTIFIC NOTES AND NEWS

J W GREEN of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, arrived at Rio de Janeiro January 3 and left January 28 after making comparisons with magnetic instruments at Vassouras

EARL HANSON of the same Department is making an extensive magnetic survey in the northern part of South America He has already ascended the Orinoco and crossed over to the Rio Negro river

A narrative by J HARLAND PAUL, entitled "The Last Cruise of the *Carnegie*" has just been published The scientific work is described in popular style The book is dedicated to Capt J P AULT who was a member of the Academy, and who lost his life with the vessel

The Carnegie Institution of Washington lectures on the magnetic field of the Earth and the Earth's atmosphere were given on the evenings of March 8, 15, and 22, by Messrs FLEMING, KENNELLY, and BARTELS, at the Administration Building of the Institution

Announcement has been made by the Carnegie Institution of Washington that Messrs TUVE, HAFSTAD, and DAHL of the Department of Terrestrial Magnetism, using high-voltage tubes, have succeeded in observing and photographing the paths made by high-speed protons They have also succeeded in making preliminary measurements of the distance the protons will travel in air, thereby obtaining a check on the law which governs their paths.

The fourteenth annual meeting of the American Society of Mammalogists is to be held in Washington May 3 to 7, 1932, the sessions for the presentation of papers, discussion, and business to convene at the National Museum. The

local committee on arrangements consists of Dr. W. M. MANN, Director of the National Zoological Park; Dr. REMINGTON KELLOGG, Assistant Curator of the Division of Mammals; ERNEST P. WALKER, Assistant Director of the National Zoological Park; and WALTER C. HENDERSON and Dr. H. H. T. JACKSON, of the Bureau of Biological Survey According to the plans of this committee, a combined reception, smoker, and movies will be held on Wednesday evening, May 4, and the annual dinner on Thursday evening, May 5. On Saturday, there will be a luncheon at the National Zoological Park, with a tour of the zoo in the afternoon.

Dr. C. LEWIS GAZIN, of Pasadena, Calif, recently appointed Assistant Curator in the Division of Vertebrate Paleontology in the National Museum, took up his duties March 1. Doctor GAZIN is a graduate of the California Institute of Technology where he also pursued his postgraduate studies. After leaving college he joined the United States Geological Survey, doing geological work in California and other western states He will take over the duties of the late Dr. J W. GIDLEY.

NOTICE TO READERS OF THE JOURNAL

A special committee has been appointed by the president of the Academy to study the problems of publication of the Journal of the Washington Academy of Sciences. The chairman is HARVEY L. CURTIS, Bureau of Standards, and the other members, C W COOKE, E A GOLDMAN, H B HUMPHREY, and R S. MCBRIDE The committee is considering first the fundamental question of the major objectives which are now, or should be, served by this Journal The committee desires to determine the wishes of the membership of the Academy and of others who subscribe for the Journal as to the relative importance of different parts or functions, the desirable frequency of publication, and other fundamental matters of policy. The committee will welcome comments on any phase of Journal policy; these should be addressed to the chairman by letter at an early date

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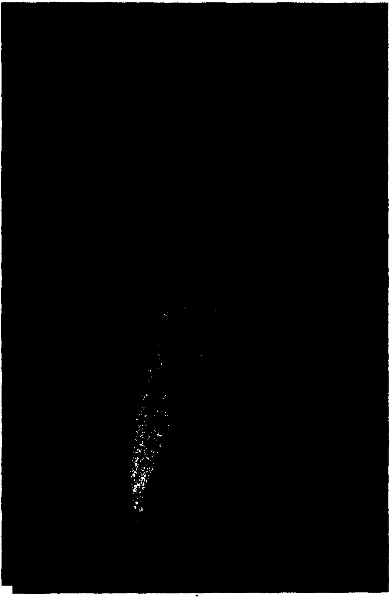
PHYSICS.—*The determination of the electrical units by mechanical measurements.*[1] HARVEY L. CURTIS, Bureau of Standards.

The Philosophical Society entrusts the preparation of most of its programs to its Committee on Communications. However, it may be said that the Society as a whole decides on the program for one meeting per year; for in selecting a president, the Society virtually determines the subject for the address, the following year, of the retiring president. Custom requires that this address be on a subject to which the speaker has given thought and attention over a period of years, and very few presidents have had more than one, or at most two, lines of endeavor which would make a suitable subject for a retiring address. Hence a year ago any one of you could have given the title of tonight's address. You have selected the subject; I will supply the treatment.

The electrical units are now a part of the c.g.s. system of units which form a practically complete and unified system for the measurement of all physical quantities. This system, except as regards mechanical units, is definitely based on the principle of the conservation of energy. As this principle was not accepted until the second quarter of the nineteenth century, a unified system of measurement has only been possible during the last hundred years. I shall attempt to show the relationship of the electrical units to the mechanical units, indicate the principles that can be employed in establishing the electrical units, and to give some of the experimental values that have been obtained. I will also give some of the historical settings.

In 1832, just one hundred years ago, was announced the first absolute measurement of an electric or magnetic quantity. In that year

[1] Received February 25, 1932 Address of the retiring president, delivered before the Philosophical Society of Washington, January 16, 1932.



HARVEY L CURTIS
President, Philosophical Society of Washington
1931

Gauss delivered before the Royal Society of Göttingen a paper entitled *Intensitas vis magneticae terrestris ad mensuram absolutem revocata.* In this paper was described a method for determining the horizontal component of the earth's magnetic field in terms of length, mass, and time. Gauss called this an *absolute* measurement, a name which is still applied when any electric or magnetic quantity is measered in terms of mechanical units. The method of Gauss is still used as a means of measuring the earth's field; in fact, it has been the most widely used method until the last decade.

Following the work of Gauss, physicists developed absolute methods for the measurement of various electrical and magnetic quantities. However, it was not till 1851 that Wilhelm Weber showed that all the electrical and magnetic units can be derived from the mechanical units, thus forming a complete system. In this monumental work, Weber not only showed the possibility of a complete electromagnetic system of units, but outlined methods for making the measurements and actually gave some experimental values for the unit of resistance. This work of Weber's marks the real beginning of absolute electrical measurements. It appeared about seven years after the opening of the first telegraph line, the first commercial application which was made of electric currents. Telegraph engineers soon began to demand suitable units by which to make electrical measurements. This demand was an important factor in establishing the units which are used today.

In order to obtain a fair perspective, let us consider the state of electrical measurements and electrical units in the decade between 1850 and 1860. At this time the only source of a continuous electric current was a primary cell. As the electromotive forces of the different kinds of primary cells are all of the same order of magnitude, no great need was felt for a method of measuring electromotive force. Results could be stated with sufficient accuracy by stating the number of cells in the circuit. The current in a circuit was either measured by a tangent galvanometer or computed by Ohm's law from the electromotive force and resistance. Hence the important requirement was a unit of resistance. During the decade under consideration two different units were extensively used. The first, proposed by Jacobi, consisted of a copper wire of a given length and diameter, the expectation being that any laboratory could construct its own standards. However, the copper of those days varied greatly in resistivity, so that laboratories found it necessary to exchange standards, if they were to be on the same basis.

The second resistance unit, proposed by Siemens, consisted of a filament of mercury having a cross-section of 1 sq. mm. and a length of one meter. This unit was far superior to any that had been previously proposed, and is the forerunner of our present international ohm. No need was felt for standards of capacitance or inductance.

The electrical instruments and methods available during the decade following 1850 were not numerous. The tangent galvanometer was available at the opening of the decade, and Thompson's astatic galvanometer became available soon thereafter. These instruments did not then exhibit the cranky behavior which is the one feature remembered by those in this audience who have used them. There are two reasons why their early behavior was more satisfactory than that of later years. In the first place the sensitivity required was not great, in the second place there were no magnetic disturbances from commercial electrical circuits and electric machinery. At the beginning of the decade, the Wheatstone bridge was available as a means of comparing resistances This is the one method of that day which still finds favor in our laboratories.

With this background, let us consider the advances which took place in the decade beginning with 1860, a decade in which our present system of electrical units was founded. In 1861, the British Association for the Advancement of Science appointed a Committee on Standards of Electrical Resistance. The Committee in its first report state that before they decided upon a unit of resistance, it would be necessary to decide upon a system of units for the measurement of all electrical quantities. After much discussion and after inviting comments from the leading physicists of the world, including our own Professor Henry, the committee decided upon the c.g s. electromagnetic system of units as proposed by Weber. At the same time the committee inaugurated experiments to determine the value which should be assigned to the new unit of resistance. In 1863 the B.A. unit of resistance was definitely established as, within experimental error, equal to one billion c.g.s. electromagnetic units.

The B.A. committee made their unit as near the absolute unit as could be determined by their experimental apparatus. However, they did not consider the exact value of the unit nearly as important as the stability of their standard. They expected their unit to remain the standard for an indefinite period and discouraged any further absolute determinations. As a matter of fact, the B.A. unit was extensively used for a quarter of a century.

The B.A. committee gave some attention to the question of a unit of capacitance, which was of some commercial importance at that time in connection with submarine cables. However, no decision was reached. The important contributions of this committee were the c.g.s. electromagnetic system of electrical units and the B A. ohm.

During the decade beginning in 1870, there was little progress in electrical units. Professor Rowland at Baltimore showed in 1878 that the B.A. unit of resistance was in error by more than one per cent, thus opening the way for the activity that followed.

In the decade that began in 1880, there was a very great increase in all activities which centered around electrical phenomena. Electric generators and motors reached a state of perfection where commercial applications were feasible. Electric lamps passed the experimental stage and furnished an outlet for the power of the "new-fangled dynamo." The telephone became an accepted means of communication. This activity in the commercial field naturally led to greater consideration of electrical units. A series of international conferences was held in Paris, at which names were given to the units, and the importance of deciding on values that agree with the absolute system was emphasized. While the values which were adopted for the units at these conferences were never extensively used, so that the direct results were small, yet the indirect results were outstanding. An important result was the stimulation of research on the units.

The next important action in regard to the electrical units was taken at the Chicago Electrical Congress of 1893, which adopted the International Electrical Units, the legal units in all civilized countries to this day. The International Electrical Units were made more definite at the London Electrical Conference in 1908, and the recommendations of this Conference were made effective by the experimental results obtained at Washington in 1910 by an international committee.

Finally, in 1927, the International Committee on Weights and Measures, to whom due authority had been given by a treaty signed by practically all civilized nations, decided that the absolute system should be adopted as the fundamental system, with material standards approximating as nearly as possible the value of the theoretical unit. All the important standardizing laboratories of the world are now trying to determine the values of their concrete standards in terms of the absolute units.

It is interesting to observe the two different points of view that are held concerning units, and how in the electrical field first one and then

the other has been dominant. One point of view is that, since the units are part of a system, they should conform as nearly as possible to their theoretical value. The other point of view is that, since there is always some experimental error in the value of a derived unit, an arbitrary value should be selected which approximates the correct value, then this arbitrary value maintained indefinitely.

Throughout the history of units, there are many interesting examples of the conflict of these two points of view. In the electrical field, there has been a shifting from one side to the other. The B. A. committee stated that the unit which they had selected was near enough for all practical purposes to the absolute unit, and no farther absolute determinations would ever need to be made. Twenty years later, the Paris Electrical Congress went on record as believing that new values should be established every ten years. Just ten years after this, the Chicago Congress adopted arbitrary standards. And now after nearly forty years more, the pendulum is again swinging back towards absolute units. The underlying causes of these changes in viewpoint are interesting, but time will not permit a discussion of them.

The methods which have been evolved for determining the electrical units of the electromagnetic system from the mechanical units are based on the magnetic effects of the current. The magnetic intensity, **H**, at any point in the neighborhood of an electric circuit, I, can be represented by the equation known as the Biot-Savart Law. This equation is

$$\mathbf{H} = \mathrm{I} \int \frac{[\mathbf{r} \times \mathbf{ds}]}{r^3}$$

where **ds** represents an element of the circuit and (**r**) is the distance from **ds** to the point at which the magnetic field is required. This integral shows that the computation of the magnetic intensity for a given current is merely a matter of geometry. Like most geometric problems, it has been accomplished for only a few forms of circuit. In some cases the result is very simple. For instance, the magnetic intensity at the center of a circular loop of radius, R, is

$$\mathbf{H} = \frac{2\,\pi\,\mathrm{I}}{R}$$

However, at any other point than the center, the value of **H** is expressed as an infinite series.

The electrical unit that follows most directly from the magnetic field of a circuit is the unit of inductance. To show the connection, consider two circuits in one of which there is a varying current having an instantaneous value i_1, and in the other an induced electromotive force e_2 resulting from the variation of i_1. Then, by definition, the mutual inductance between the circuits is given by the equation

$$e_2 = M \frac{d i_1}{dt}$$

Also the induced electromotive force is related to the magnetic flux, φ_2, through the second circuit by the relation

$$e_2 = \frac{d \varphi_2}{d t}$$

Equating and integrating

$$M = \varphi_2/i_1$$

Hence the mutual inductance is equal to the magnetic flux through the second circuit caused by unit current in the first circuit. But the magnetic flux is the integral, over any surface which is bounded by the second circuit, of the normal component of the magnetic induction. In the electromagnetic system of units the magnetic induction in a vacuum is numerically equal to the magnetic intensity. It follows that φ_2 depends upon i_1 and certain geometric properties of the two circuits. Hence the mutual inductance between two circuits in a vacuum depends only on the geometric properties of the two circuits, although the underlying phenomena are magnetic.

The mutual inductance, M, between any two filamentary circuits which are in a vacuum can be computed by means of Neumann's integral, which is

$$M = \int \frac{ds_1\, ds_2 \cos \epsilon}{r}$$

where ds_1 is an element of one circuit, ds_2 an element of the second circuit, ϵ the angle between the directions of the elements, and r the distance between the elements. While this integral contains nothing but geometric quantities, yet the evaluation in any practical case is difficult, and has been accomplished for only a few geometric forms Moreover, some of these in any practical size give only a very small value of mutual inductance. A form important at the present time is

known as Campbell's absolute mutual inductor. The primary consists of a long solenoid with the center portion omitted. The secondary is a coil of many turns located symmetrically with respect to the solenoid, and of considerably greater diameter. The diameter of the secondary is so chosen that its exact value is not important. The important measurements are the diameter, length, and pitch of the winding on the solenoid. The National Physical Laboratory of England has measured three inductors of this type, each designed to have an inductance of about 10,000 microhenrys. Assuming one of these to be correct, the maximum difference between the measured and computed values of the other two was 0.1 microhenry, or ten parts in a million. Hence the Campbell type of mutual inductor can be constructed with sufficient accuracy to give a very precise value of the computed inductance.

The self inductance of a circuit cannot be expressed by an integral as simple as Neumann's integral for mutual inductance. The reason for this is that in a mutual inductance, the circuit can usually be considered as concentrated in a filament, whereas in a self inductance, the finite cross-section of the circuit must be considered. One method of obtaining a suitable integral for expressing the self inductance of a circuit is to consider the circuit divided into an infinite number of filaments of infinitesimal cross-section Now the position of any two filaments can be expressed in terms of coordinates which are applicable to a cross-section, and the mutual inductance between these two filaments determined by Neumann's formula. Then the average value of the mutual inductance between one filament and all the others can be determined by integration over the cross-sectional area and dividing by the area. Finally the mutual inductance between the average filament and all the other filaments of the cross-section can be determined by again integrating over the cross-sectional area and dividing by the area. This final average mutual inductance is the self inductance of the circuit. To express this as an integral let L be the self inductance of a circuit having a cross-section S in which any elements of the two filaments may be represented by ds_1 and ds_2, then

$$L = \frac{1}{S^2} \iint dS \iint dS \iint \frac{ds_1 \, ds_2 \cos \epsilon}{r}$$

where r is the distance between ds_1 and ds_2 and ϵ the angle between their directions. Again this integral involves only geometrical quan-

tities. However its evaluation is so difficult that there are relatively few forms for which the self inductance can be computed.

The one form of self inductor for which the self inductance has a useful value and for which an accurate formula for the self inductance is known is a single layer solenoid. A solenoid can be accurately constructed. Also precision measurements can be made of the diameter of the solenoid, the pitch of the winding, and the diameter of the wire, the three dimensions that are required for computing the inductance. The Bureau of Standards has constructed a solenoid, the inductance of which can, it is believed, be computed with an error of only a few parts in a million. However, no direct check between two similar solenoids has been made.

The inductance of an absolute standard can be computed from measurements of length only, and hence is simpler than any of the other electrical units. These standards are useful not only for establishing working standards of inductance, but as a basis for establishing other electrical units. This latter phase will be discussed as necessity arises

The electrical unit for which an accurate value is most needed, on which the most effort has been expended, and for which the results have been most unsatisfactory, is the ohm. The number of methods which have been devised for its measurement are numerous. The underlying principle is much the same in all of them. This principle will first be stated, then several applications to specific methods given.

The underlying principle may be stated as determining the ratio of induced electromotive force to current in a circuit where the electromotive force and current can be determined in terms of the same magnetic or electric quantities. Since the same magnetic or electric quantities are used in determining both the current and electromotive force, they will disappear in the ratio, leaving the resistance in terms of mechanical quantities. In order to measure current and electromotive force in the same quantities, it is necessary to assign a numerical value to the ratio of the magnetic intensity and magnetic induction of a vacuum. This value is usually taken as unity, which is equivalent to stating that the permeability of a vacuum is unity.

The underlying principle of the methods for the aboslute measurement of resistance can be illustrated by one of the methods proposed by Wilhelm Weber. Consider a coil having N turns, each of area A, to rotate with an angular velocity, ω, around a vertical axis which passes through a diameter of the coil. The induced electromotive

force, e, at any instant, t, in a place where the horizontal component of the magnetic induction of the earth's field is B, is

$$e = B\,N\,A\;\omega \sin \omega\, t$$

The average value, E, of the electromotive force for a half cycle is, since $\omega = \frac{2\pi}{T}$

$$E = \frac{4B\,N\,A}{T}$$

where T is the period. If this coil is provided with a suitable commutator and connected to a tangent galvanometer, the current through the galvanometer consists of a series of half waves, all the current being in one direction. The average value of this current when measured with a tangent galvanometer having n turns of radius r, at a place where the magnetic intensity of the earth's field is H, is

$$I = \frac{r\,H}{2\,\pi\,n} \tan \theta$$

where θ is the angular deflection of the galvanometer magnet. If the resistance R of the entire circuit is taken as the ratio of the average electromotive force to the average current, then, since B and H are numerically equal,

$$R = \frac{E}{I} = \frac{4B\,N\,A/T}{H\,r\,\tan \theta/2\,\pi\,n} = \frac{8\,\pi\,n\,N\,A}{T\,r\,\tan \theta}$$

where T is the time of a revolution of the coil. This equation shows that R is determined in terms of mechanical units. If all the quantities in the equation are expressed in dimensional units, then $[R] = [L/T]$, which is responsible for the statement that a resistance is a velocity.

The above method is not capable of giving results of high accuracy. It has been introduced solely to illustrate the fundamental principles involved in any absolute ohm determination, and to show the type of apparatus used in the earliest experiments

Another historical method is the combination into a single instrument of the earth inductor and the tangent galvanometer of the preceding method. A magnetic needle is suspended at the center of a coil mounted to rotate about a vertical diameter. As the coil rotates, the magnet is deflected because the earth's field induces a current in

the coil, which in turn produces a magnetic field at the center of the coil that is at right angles to the earth's field. The amount of deflection depends on the diameter of the coil, its velocity and its resistance. This method was independently proposed about 1860 by Wilhelm Weber and by Lord Kelvin. It was first used by Maxwell and his associates to establish the B. A. ohm. Since then it has been used for more accurate determinations, but it is not capable of giving results of the highest precision.

Perhaps the most direct method for the absolute measurement of the ohm is the one proposed by Lorenz about 1870. This method employs a form of homopolar generator with air-cored magnets for generating an electromotive force which is compared with the fall in potential produced by a current in a resistance The armature of the generator consists of a disc mounted to rotate around its axis. The magnetic field of the generator is produced by a coil, solenoid, or group of coils which are placed with their axes coinciding with the axis of the disc. Then as the disc rotates, the same electromotive force is produced in every radius of the disc. The electromotive force in each radius is equal to the magnetic flux through the disc divided by the time of a revolution. But the flux for unit current in the coils is equal to the mutual inductance, M, between the coils and a circle which coincides with the circumference of the disc. Hence the electromotive force E between the center and the circumference of the disc is given by the equation

$$E = \frac{M\ I}{T}$$

where I is the current in the coils and T is the time of a revolution. This electromotive force is balanced against the drop in potential over a resistance, R, in series with the coils. Hence

$$E = IR = \frac{M\ I}{T}$$

or

$$R = \frac{M}{T}$$

Now the value of M can be computed from measured dimensions of the coil and disc.

The Lorenz method is considered by many as one of the best that

has ever been devised. One difficulty with the method is the very small value of the induced electromotive force, generally, only a few millivolts. At the National Physical Laboratory a determination in 1914 by F. E. Smith gave a result with a probable error of only three parts in a hundred thousand.

While it is not the purpose here to discuss all the various methods that have been proposed and used for absolute ohm determinations, yet the picture would be so incomplete without a mention of alternating current methods that one of these methods will be described. Alternating current measurements have been largely developed since the days when it was fashionable to make absolute ohm determinations. Hence, while a number of alternating current methods have been proposed, only one satisfactory determination has been completed. This determination was made at the Physikalisch-Technische Reichsanstalt of Berlin, although the method was first suggested by Rosa, a former president of this Society

The Rosa method employs a self inductance, the value of which can be computed from its linear dimensions and can be measured by an alternating current bridge in terms of capacitance and resistance. The capacitance is then measured in terms of resistance and time by Maxwell's method. From these two measurements the resistance of a resistor can be determined in terms of a self inductance, a time, and the ratios of two pairs of resistances. The method assumes that the value of the capacitance is the same when measured by alternating current as when measured by charging and discharging. This assumption holds only when the capacitor has no absorption, a condition that can be met only with an air capacitor.

During the past 80 years about 25 determinations of the absolute value of the ohm have been made Fortunately it is possible satisfactorily to compare the results of these determinations. About the time of the first absolute determinations, Siemens suggested the use of a mercury column having a cross-section of one sq. mm. and a length of a meter as a unit of resistance. From that time to this, results of absolute determination have been expressed in such a manner that they can be readily reduced to the length of the standard mercury column. In two of the latest results, the errors connected with the mercury column appear to be as large as those of the apparatus for the absolute measurement In this case, however, an interchange of wire standards was made about the time of the experimental work, so that the relative value is known.

The results of all determinations are shown in Fig. 1. The abscissas are time in years, while the ordinates are length of the standard mercury column in centimeters. This figure shows that the early determinations differed from one another by several per cent. There was a considerable increase in accuracy following 1880 More than half of the determinations were made between 1880 and 1895. During the twentieth century there have been but two satisfactory determinations. These show that the length of the standard mercury

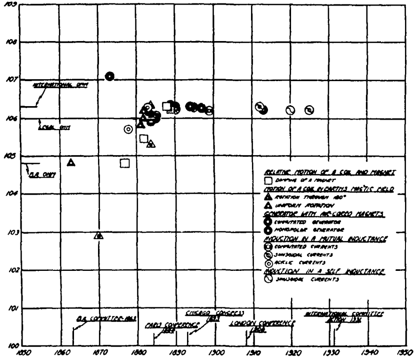


Figure 1 —Length of a column of mercury having a resistance of one ohm as determined at various times and by various methods

column corresponding to an absolute ohm is about 106 245 cm., whereas the international ohm specifies a length of 106 300 cm. The International Committee of Weights and Measures has decided to abandon the International Ohm in the near future.

The electrical unit which was first determined in terms of mechanical units and which has been most often so measured is the ampere. In fact for more than a quarter of a century most measurements of current were by absolute methods. In 1837, Poulliet devised the

tangent galvanometer which permitted a current to be measured in terms of the deflection of a magnetic needle, the radius of the galvanometer coil, and the horizontal component of the intensity of the earth's magnetic field. As Gauss had previously shown that the intensity of the earth's magnetic field can be measured in terms of mechanical units, the tangent galvanometer permits the absolute measurement of current.

It is difficult for physicists and engineers of today to appreciate the important part that the tangent galvanometer played in electrical measurements in the years between 1850 and 1880. The instrument was simple, rugged, and sufficiently sensitive. There was little trouble from stray magnetic fields. The value of the horizontal component of the magnetic intensity of the earth's field was given in handbooks with sufficient accuracy for most measurements. Withal it was a convenient, reliable, and satisfactory instrument. However, with the advent of the electric generator and systems for the distribution of electric power, the tangent galvanometer rapidly gave way to other methods of measuring current. One of the attempts to adapt a tangent galvanometer to the requirement of measuring large currents was made at Cornell University. The instrument was called "The Great Tangent Galvanometer of Cornell." The coils were two meters in diameter, made from copper rod nearly 2 cm. in diameter. It was housed in a non-magnetic building, made mostly of copper. None of the results obtained with this instrument have been preserved.

In the decade following 1880, the tangent galvanometer lost its standing as a current-measuring instrument. The two important electrical standards became the standard resistance and the standard cell. In commercial and laboratory measurements, a current came to be measured either by the fall in potential which it produced in a known resistance, or by the amount of copper or silver deposited from an electrolytic solution. But to determine initially the electromotive force of a standard cell, or the amount of silver or copper deposited by unit current, some type of absolute current-measuring instrument is necessary. In addition to the tangent and the sine galvanometers, two types of instrument have been used, the current balance and the torsion electrodynamometer.

In a current balance, the force of attraction between two coils through which a current is flowing is balanced against the gravitational attraction of a known mass. Several arrangements of coils have been used. In the one proposed by Lord Rayleigh, a coil of moderate size and relatively few turns is suspended, with its plane horizontal, from

the pan of a balance, flexible leads bringing the current to the coil. Two much larger coils are supported, one above, the other below the moving coil, so that their axes coincide with the axis of the suspended coil and with the distance between the suspended coil and each fixed coil such that when a current is flowing, the force on the suspended coil is a maximum. When the coils are in this position of maximum force, the force of attraction, F, for a current I is

$$F = I^2 f\left(\frac{a}{A}\right)$$

where a is the radius of the smaller coil, A the radius of each of the larger coils, and $f\left(\frac{a}{A}\right)$ is a known function involving only the ratio of the two radii. This force is balanced by a mass, m, having a weight mg, where g is the acceleration of gravity. It follows that

$$I^2 = \frac{m\,g}{f\left(\frac{a}{A}\right)}$$

Of the quantities on the right hand side of the equation, the mass, m, can be compared with the standard kilogram, the value of g must be experimentally determined at the place where the weighings are made, and the ratio of the radii of the two coils must be evaluated The comparison of the mass with the standard kilogram is comparatively simple. The experimental determination of the absolute value of gravity is exceedingly difficult, so that the value at a given place is generally found by comparison with that at some place where gravity has been carefully determined by an absolute method. For more than thirty years, gravity determinations for all countries of the world have been referred to Potsdam, Germany, where a very careful absolute determination was made during the latter part of the nineteenth century. In comparing gravity at one place with that at another, appreciable errors may enter. One of the largest sources of possible error in recent absolute current determinations has been the uncertainty in the value of gravity.

To determine the ratio of the radius of the small coil to that of one of the large coils, the two coils are mounted concentrically in a vertical plane which is parallel to the horizontal component of the earth's field. At the common center is suspended a small magnetic needle. A current is sent through the small coil producing a deflection of the

magnetic needle. Then a current is sent through the large coil, of such magnitude and direction that the deflection is reduced to zero. Knowing the number of turns on each coil, and measuring the ratio of the currents, the ratio of the radii is given by the equation

$$\frac{a}{A} = \frac{n_1 I_1}{n_2 I_2}$$

Hence measuring the ratio of the radii is reduced to measuring the ratio of two currents, a comparatively simple process

One difficulty with this method for the absolute measurement of a current is the extreme precision required in the weighing. As an illustration, the suspended coils used by Rosa, Dorsey and Miller all weighed more than a kilogram. The force caused by a reversal of the current was about 5 grams. Hence for an accuracy of one in a million in the current the weighings had to be made to 0.01 mg. For a weight of a kilogram on the balance beam, this means that the balance must be sufficiently sensitive to weigh to a part in a hundred million. Moreover, this weighing must be made with current in the suspended coil, which produces heating and the accompanying air currents.

A torsion electrodynamometer measures, in terms of mechanical units, the torque between two coils carrying a current. This method has often been used, but time prevents a discussion of its principles.

There are two methods by which the result of an absolute current measurement can be preserved, one by determining the electrochemical action in an electrolytic cell, the other by comparing the potential drop produced in a standard resistance with the electromotive force of a standard cell. The first method has been used since the early days of measuring electric currents; the second has been employed in recent absolute determinations. The first is the more useful in comparing results over a long period of years, the second is more valuable for electrical measurements in the laboratory.

Before 1870, the electrolysis of water was frequently used to preserve the results of absolute electrical measurements; it is most unsatisfactory for this purpose. In 1873 Kohlrausch suggested the use of the silver voltameter Following the Paris Conference of 1881, the silver voltameter was greatly improved and has been extensively employed. Since that time, the results of all important absolute measurements of current either have been expressed in terms of the number of milligrams of silver deposited by a current of one ampere flowing for one second or can be reduced to that basis. These results are shown in Fig. 2. It is interesting to note that the last published result is nearly

twenty years old. The value found, 1.11804 mg. of silver per coulomb, differs by only four parts in a hundred thousand from the value selected by the London Electrical Congress of 1908 for the value of the international ampere: viz., 1.11800 mg/coul.

The value of the absolute volt has usually been obtained as the fall in potential produced by an absolute ampere in an absolute ohm. No absolute measurement in the electromagnetic system has ever been attempted. However it is possible to measure a voltage in electrostatic units, and to convert the result into electromagnetic units by

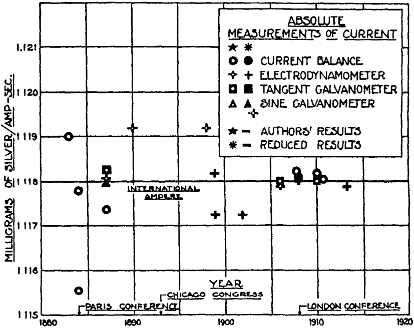


Figure 2.—Rate of deposition of silver by a current of one ampere as determined at various times and by various methods

means of the experimental constant (usually designated as V, but sometimes as C) which serves to convert from electrostatic to electromagnetic units and vice versa The method of using an attracted disc electrometer was suggested by Lord Kelvin, but there are no important published results. As the attraction between two discs varies as the square of the potential difference between them, the method requires the use of relatively high voltages.

The determination of a capacitance in absolute microfarads is usually accomplished by reference to other absolute electrical units.

There are three distinct methods of procedure. In the first method a capacitance is compared with an inductance and at least two resistances; in the second, with a resistance and time; in the third, with an inductance and the frequency of an alternating current. No discussion of these methods will be attempted. It is sufficient to note that for most capacitors, the different methods yield different results. When the dielectric of the capacitor is a vacuum or an un-ionized gas, then the three methods give identical results. Only capacitors with such dielectrics are suitable for use in absolute electrical measurements.

The absolute coulomb is determined either as the product of current and time, or as the product of capacitance and voltage. The first is used in connection with an unvarying current, the second with a varying current. No experimental work has been carried out to show that the two methods give identical results.

No discussion of absolute measurements is complete which does not mention the experimental constant V, which determines the ratio of each unit in the electromagnetic system of units to the corresponding unit in the electrostatic system. The latest experimental result, by Rosa and Dorsey, gives a numerical value for V which, within experimental error, is identical with the numerical value of Michelson's latest value for the velocity of light. This constant is not only of practical importance, as already shown, but is fundamental in the electromagnetic theory of light.

Absolute electrical measurements have for their primary object the establishment of electrical units which form a part of a complete system of units for measuring all physical quantities Methods have been developed by which this object can be accomplished even with the extreme accuracy which is demanded at the present time. However, most absolute measurements of precision are time-consuming, and require very special equipment. Only the national laboratories have the men and facilities for this work. Hence, relatively few new results are to be expected in the immediate future.

In closing I wish to pay tribute to those members and former members of this Society who have made important contributions to absolute electrical measurements. Omitting those who are now active in this field, and who may at any time describe their work to you, one thinks immediately of Rosa, Dorsey, and Grover as men who have in recent years made important contributions. In particular, the late E. B. Rosa, former president of the Society, did much to advance our

knowledge of absolute measurements. However, in choosing a subject for a presidential address, he was considerate of the Society, and decided not to bore them with an address on absolute electrical measurements.

CHEMISTRY.—*The hydration of the solute ions of the heavier elements.*[1] L. H. FLINT. Bureau of Plant Industry. (Communicated by G. N. COLLINS.)

In the first paper[2] of a proposed series dealing with the hydration of solute ions it has been shown that an assumed inverse integral system of hydration derived through the extension of Graham's Law to solutions appears to characterize the stable element-ions of the first quarter of the periodic system as judged by three aspects of solution phenomena,—electrical conductivity, freezing-point depression and boiling-point elevation. In the system as therein developed the weight of the element appeared to be modified incident to ionization; the respective hydration seemed entirely dependent upon the weight, the hydrating water molecules were considered as uniting with the atoms to form molecular ions of solute distinct from the solvent; and complete ionization was indicated at all concentrations.

In studying the hydration characteristics of the heavier element ions the most natural suggestion growing out of these previous considerations is to project an analogous system of inverse integral hydration throughout the periodic system of elements. In accordance with this suggestion values corresponding to the treatments given for the lighter elements in Table 1 of the first paper have been worked out and grouped herewith in Table 1,—each section comprising the elements of a quarter of the periodic system. As was the case in connection with the lighter elements of the first quarter, many of the elements included are not known as stable ions in aqueous solutions. However, since the assumed hydration appears to be conditioned by weight as modified by ionization, the full set of values seems desirable as a reference.

In the above table the assumed hydration in terms of water molecules per ion is given in the fifth column. The calculated weight values for the unhydrated and hydrated states are given in the third and seventh columns respectively, while the velocities corresponding to these weight values are given in the fourth and eighth columns.

[1] Received February 24, 1932

[2] *The hydration of the solute ions of the lighter elements.* This JOURNAL **22**. 97–119 1932

TABLE 1.—WEIGHT, HYDRATION AND VELOCITY VALUES FOR A POSTULATED INVERSE INTEGRAL HYDRATION SYSTEM AS APPLIED TO THE HEAVIER ELEMENTS

A N	E	Assumed as W 2 x A N	V_1	Postulated Number of Water Molecules	Mol Wt. Water of Hydration	Mol Wt Hydrated Molecule	V_2
23	V	46	1475	23	414	460	466
24	Cr	48	1443	22	396	444	475
25	Mn	50	1414	21	378	428	484
26	Fe	52	1387	20	360	412	494
27	Co	54	1360	19	342	396	502
28	Ni	56	1336	18	324	380	513
29	Cu	58	1313	17	306	364	524
30	Zn	60	1290	16	288	348	536
31	Ga	62	1270	15	270	332	549
32	Ge	64	1250	14	252	316	563
33	As	66	1230	13	234	300	578
34	Se	68	1212	12	216	284	594
35	Br	70	1195	11	198	268	611
36	Kr	72	1178	10	180	252	630
37	Rb	74	1162	9	162	236	651
38	Sr	76	1147	8	144	220	675
39	Y	78	1132	7	126	204	700
40	Zr	80	1118	6	108	188	729
41	Cb	82	1105	5	90	172	763
42	Mo	84	1091	4	72	156	800
43	Ma	86	1078	3	54	140	846
44	Ru	88	1065	2	36	124	899
45	Rh	90	1054	1	18	108	963
46	Pd	92	1042	0	0	92	1042
46	Pd	92	1042	23	414	506	445
47	Ag	94	1031	22	396	490	452
48	Cd	96	1020	21	378	474	460
49	In	98	1010	20	360	458	467
50	Sn	100	1000	19	342	442	476
51	Sb	102	992	18	324	426	485
52	Te	104	982	17	306	410	494
53	I	106	972	16	288	394	502
54	Xe	108	963	15	270	378	514
55	Cs	110	954	14	252	362	526
56	Ba	112	945	13	234	346	538
57	La	114	936	12	216	330	551
58	Ce	116	929	11	198	314	565
59	Pr	118	922	10	180	298	580
60	Nd	120	914	9	162	282	595
61	Il	122	906	8	144	266	613
62	Sm	124	898	7	126	250	631
63	Eu	126	891	6	108	234	654
64	Gd	128	884	5	90	218	678
65	Tb	130	878	4	72	202	704
66	Dy	132	871	3	54	186	733

TABLE 1 —WEIGHT, HYDRATION AND VELOCITY VALUES FOR A POSTULATED INVERSE INTEGRAL HYDRATION SYSTEM AS APPLIED TO THE HEAVIER ELEMENTS —*Concluded*

A N.	E	Assumed as W 2 x A N	V_1	Postulated Number of Water Molecules	Mol Wt Water of Hydration	Mol Wt Hydrated Molecule	V_2
67	Ho	134	864	2	36	170	768
68	Er	136	858	1	18	154	806
69	Tm	138	851	0	0	138	851
69	Tm	138	851	23	414	552	426
70	Yb	140	845	22	396	536	432
71	Lu	142	839	21	378	520	439
72	Hf	144	833	20	360	504	445
73	Ta	146	828	19	342	488	453
74	W	148	822	18	324	472	460
75	Re	150	817	17	306	456	468
76	Os	152	811	16	288	440	477
77	Ir	154	806	15	270	424	486
78	Pt	156	801	14	252	408	495
79	Au	158	796	13	234	392	505
80	Hg	160	790	12	216	376	516
81	Tl	162	786	11	198	360	527
82	Pb	164	781	10	180	344	539
83	Bi	166	776	9	162	328	552
84	Po	168	772	8	144	312	566
85		170	768	7	126	296	581
86	Rn	172	763	6	108	280	598
87		174	758	5	90	264	615
88	Ra	176	754	4	72	248	635
89	Ac	178	750	3	54	232	657
90	Th	180	746	2	36	216	680
91	Pa	182	741	1	18	200	707
92	U	184	737	0	0	184	737

The procedure corresponds precisely with that employed in Table 1 of the previous paper, and represents the extension of Graham's Law of the Diffusion of Gases to solute ions considered as of two potential states (1) hydrated and (2) unhydrated.

In examining evidence for the validity of the system as applied to the lighter element ions it was indicated that the apparent rate of decrease in specific molecular electrical conductivity with increasing concentration was subject to interpretation as an index of the rate at which the solvent becomes modified by the hydrating solute. The apparent rate of decrease thus constituted a convenient measure of hydration, and in the present paper this method of inquiry will be used exclusively in the examination of evidence for the validity of the system as applied to the heavier element ions and represented in Table 1.

With regard to the correspondence of the calculated and observed bases it may be noted that the concentrations used in the taking of measurements of electrical conductivity characteristically involve solutions made up to 1000 cc. rather than the 1000 grams involved in prediction. In dilute solutions the volume method is practically identical with the weight method, but in concentrations as great as 1.0 molecular the differences between the two systems are appreciable. When these differences are enhanced by hydration, particularly with ions having a high hydration, the amount of free solvent present in a one-molecular solution based on volume becomes difficult to evaluate with great precision. Then, again, observed measurements involve the use of the observed combining weights of the elements. As previously noted, these depart from the combining weights suggested under the hydration and weight-change hypotheses, and in the heavier elements the departure becomes appreciable. It seems desirable to consider the validity of the suggested hydration before specifically considering the validity of observed combining weights,—but it will be apparent that in view of the divergent weight bases represented in calculated and observed values a further source of discrepancy may be encountered. In general the use of the volume method for calculating concentration effects a dilution from the concentration calculated on the weight basis, while the use of the observed combining weights effects a concentration over the calculated basis. There is thus a tendency for these two factors to compensate each other with respect to the theoretical bases of calculation,—but under the circumstances an approximate agreement between observed and calculated values is all that may reasonably be anticipated, even were the hydration values known to be correct.

In examining observed conductivity measurements with reference to the values suggested in Table 1 we may assume a familiarity with the general treatments described in connection with the consideration of the lighter element-ions in the first paper.

Chromic Chloride, $CrCl_3$. The summation weight representing the solute in a 1.0 molecular solution of chromic chloride, $CrCl_3$, may be derived from Tables 1 of this and the previous paper, as follows.

Cr = 48, Cr^{+++}	= 54, with 19 H_2O,	mol. wt. hyd.	= 396
Cl = 34, Cl^-	= 32, with 7 H_2O,	mol. wt. hyd.	= 158
Cl = 34, Cl^-	= 32, with 7 H_2O,	mol. wt. hyd.	= 158
Cl = 34, Cl^-	= 32, with 7 H_2O,	mol wt. hyd.	= 158
		Summation wt.	= 870

From this value the relative weight of solvent present may be derived as

$$1000 - 870 = 130, \text{ or } 13\% \text{ solvent}$$

Observed values for the specific molecular conductivity of $CrCl_3$ are available as follows: 1.0 mol. conc., 0°C.[3] = 45.4, .000244 mol. conc., 0°C.[4] = 229.73, 45.4 ÷ 229.73 = 1977 or 19.77%. The observed conductivity at .000488 mol. conc is 214.48 and a higher value than 229.73 is thus indicated for "zero" concentration. Considering this fact the order of agreement is such as to constitute evidence in substantiation of the postulated system of hydration.

Copper Chloride, $CuCl_2$. The summation weight representing the solute in a 1.0 molecular solution of copper chloride, $CuCl_2$, may be calculated from Tables 1 of this and the previous paper, as follows:

Cu = 58,	Cu^{++} = 62,	with 15 H_2O, mol. wt hydrated	= 332
Cl = 34,	Cl^- = 32,	with 7 H_2O, mol. wt. hydrated	= 158
Cl = 34,	Cl^- = 32,	with 7 H_2O, mol. wt. hydrated	= 158
		Summation wt.	= 648

From this value the relative weight of solvent present may be derived as

$$1000 - 648 = 352, \text{ or } 35.2\% \text{ solvent}$$

Observed values for the conductivity of $CuCl_2$ at 0°C. may be cited as follows[5] volume = 1.28, conductivity = 59.3, volume .76, conductivity = 48.22; at zero concentration, conductivity = 165.[6] By interpolation, volume at 1.0 = conductivity at 1.0 mol conc. = 53.3. The relative conductivity may be derived as 53.3 ÷ 165 = .323, or 32.3%. The order of agreement (35.2% as calculated, 32.3% observed) appears to constitute evidence that the Cu^{++} ion in a solution of copper chloride hydrates with 15 molecules of water as suggested by the postulated system.

Strontium Chloride, $SrCl_2$. The summation weight representing the solute in a 1.0 molecular solution of strontium chloride, $SrCl_2$, may be calculated from Tables 1 of this and the previous paper, as follows.

[3] Int Crit Tables, Vol 6

[4] Jones, H C, Carn Inst Wash Pub #170, p 62

[5] Jones, H C and Getman, F H Am Chem Jour 31: 327 1904

[6] Jones, H C and Bassett, H P, on the other hand give 120.0 as the value (Carn Inst Wash Publ #180, p 73) The use of this value as a base gives a somewhat higher figure than 32.3%.

Sr = 76, Sr^{++} = 80, with 6 H_2O, mol. wt. hydrated	=	188
Cl = 34, Cl^- = 32, with 7 H_2O, mol. wt. hydrated	=	158
Cl = 34, Cl^- = 32, with 7 H_2O, mol. wt. hydrated	=	158
Summation wt.	=	504

From this value the relative amount of solvent present may be derived as

$$1000 - 504 = 496, \text{ or } 49.6\% \text{ solvent}$$

Observed values for the conductivity of $SrCl_2$ in aqueous solutions at 0°C., may be cited as follows:[7] 1.0 mol. conc. = 71 23; .000488 mol. conc. = 133.9. The relative value at 1.0 mol. conc. may be derived as

$$71.23 \div 133.9 = .532, \text{ or } 53.2\%$$

The order of agreement (by calculation 49.6%, by observation 53.2%) appears to constitute evidence that the strontium ion, Sr^{++}, hydrates with 6 molecules of water as predicted by the system being tested.

Cadmium Chloride, $CdCl_2$. The summation weight representing the solute in a 1.0 molecular solution of cadmium chloride, $CdCl_2$, may be calculated from Tables 1 of this and the previous paper, as follows:

Cd = 96, Cd^{++} = 100, with 19 H_2O, mol. wt. hydrated	=	442
Cl = 34, Cl^- = 32, with 7 H_2O, mol wt. hydrated	=	158
Cl = 34, Cl^- = 32, with 7 H_2O, mol. wt. hydrated	=	158
Summation wt.	=	758

From this value the relative weight of solvent may be derived as

$$1000 - 758 = 242, \text{ or } 24.2\% \text{ solvent}$$

Observed values for the conductivity of aqueous solutions of cadmium chloride, $CdCl_2$, at 18°C., may be cited as follows:[8] 1 0 mol. conc. = 22.4; .005 mol. conc = 91. The relative value at 1.0 mol. conc. may be derived as 22.4 ÷ 91 = .246, or 24 6%. The value at "zero" concentration would be somewhat higher than 91, yet the order of agreement (24.2% calculated, 24.6% observed) appears to indicate that in aqueous solutions of cadmium chloride the cadmium ion, Cd^{++}, hydrates with 19 water molecules as suggested by the extension of the hydration system into the third quarter of the periodic system.

There does not appear to be any electrolyte involving a representative element-ion of the group designated in Table 1, which is hydrated and yet soluble to the extent of a 1.0 molecular solution. On

[7] Jones, H. C, Carn Inst. Wash For 1 0 mol conc Pub #180, p 64; for 000488 mol conc Pub #170, p 39

[8] Kohlrausch, F und Holborn, L *Leitvermögen der Elektrolyte*, p 161.

this account the consideration of the validity of the tabulated values (except insofar as analogy may be invoked) must be deferred until a subsequent inquiry into the hydration of the nitrate ion, NO_3^-, and other molecular ions.

The order of agreement noted in the foregoing comparisons appears to constitute evidence for the assumed hydration of the involved ions. However, the further extension of the study leads to the suggestion that not all solute ions are hydrated,—a suggestion which will be considered in the next paper of this series.

PALEOBOTANY.—*A new* Drepanolepis *from Alaska.*[1] EDWARD W. BERRY, Johns Hopkins University.

Some years ago I made a preliminary report on a few specimens collected by F. H. Moffit from the northeast quarter of Quadrangle 601, Chitina valley, Alaska. (U. S. Geological Survey localities 7938, 7939, 7940.) One of these is of special interest in that it represents a type of plant hitherto unknown from North America. It may be described as follows

Drepanolepis reniformis n sp

Figure 1

Lax cone or open strobilus of undetermined length, at least 10 centimeters long and about 1 5 centimeters in diameter The axis is relatively slender when account is taken of the size and consistency of the appendages, it being not over 2 millimeters in diameter as preserved. The appendages are well spaced and are probably arranged spirally, although this is an assumption based on analogy which the term cone suggests, since the actual specimens are approximately two ranked as preserved in the rock. The essential portion of the appendages is borne on relatively stout and usually slightly recurved peduncles about 1 millimeter in diameter and about 2 millimeters in length, and consist of a round or elliptical body with a marked concavity on either side of the base, which usually results in a marked basal sinus in the outline, which is therefore more or less reniform, and it is this feature which has suggested the specific name. Their length is about 6 millimeters and the maximum width about 7 millimeters They are at least 2 millimeters in maximum thickness, evenly rounded, and consist of two parts—an inner, evenly rounded, smooth surfaced seed or stone, which is covered with a thick carbonized exterior like a shell or the ligneous testa of a drupe This outer covering fits the interior object closely and appears to be a completely enclosing envelope It is flabellately and dichotomously veined, and these veins appear to extend through its thickness, since they are the same on the inner concave and the outer convex surfaces (of different specimens) This outer layer fits closely on the enclosed seed or stone, from which it breaks away in irregular patches

[1] Received March 10, 1932.

In none of the specimens, of which there are several in the collection, can the two faces of an individual appendage be seen, but it is my impression that the covering layer is a complete envelope and is not of the nature of a cone scale. In Nathorst's account of the Spitzbergen material which he referred to this genus he adds after seed "(or sporogonium)", but there can be no doubt that the Alaska material is not a sporogonium, but a seed or drupe. In the Spitzbergen material the appendages are interpreted as scales, and the seeds (?) are smaller than the scales and located near their bases

Possibly a new genus should be erected for the Alaska material, but in view of the complete uncertainty regarding its botanical position, and the lack of

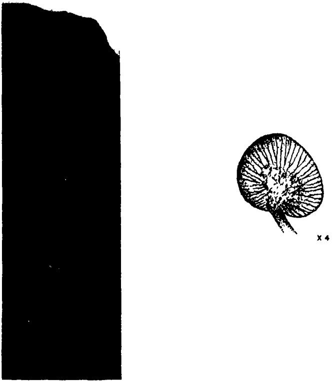


Fig 1 —*Drepanolepis reniformis* Photograph of strobilus, natural size, and drawing of a single sporophyll, enlarged

certainty in the interpretation of the Spitzbergen species as seed-bearing scales, and of that from Alaska as completely enclosed seeds or drupes, it seems unwise to suggest a new genus, especially as the Alaska form agrees with *Drepanolepis* in general habit and size, in stalked appendages containing a rounded more or less inflated seed (or drupe) which is wholly or partially enclosed in a veined envelope

A great many superficially similar fossil objects have been described from rocks of Jurassic and Lower Cretaceous ages, such as the various species of *Stenorrhachis* Saporta, *Schizolepis* Braun, etc. Some of these objects appear to be definitely cycadaceous, others ginkgoalian, and others uncertain If the Alaska species has the seeds completely enclosed as suspected, it would be fascinating to consider it angiospermous, although it should not be forgotten that if the whole appendage is a simple seed such a conclusion is not required. In this connection the material under discussion shows a superficial resemblance to the lower Jurassic genera *Caytonia* and *Gristhorpia* in which Thomas[2] has worked out the structure, and for which he has proposed the order Caytoniales, and which he regards as ancient angiosperms

These two genera differ from the Alaska fossil in having the carpels pinnately arranged on a dorsiventral axis, and these carpels contain many seeds Indeed, as I understand Thomas's hypothesis[3] of the origin of angiosperms it would be most difficult to conceive of a single seeded carpel in the early stages of the evolution of carpellary structure On the other hand such a situation is equally difficult in the classic hypothesis of the origin of carpels,[4] or in those advanced in recent years by Vuillemin[5] or Eames [6]

Nathorst described two species of *Drepanolepis*, *Drepanolepis angustior*[7] based on *Carpolithes striolatus* Heer[8] which was found in the middle and upper Jurassic of Spitzbergen, and *Drepanolepis rotundifolia*[9] based on *Phyllocladites rotundifolius* Heer[10] which came from the upper Jurassic and the lower Cretaceous of the same region. Probably representing a third species is *Phyllocladites* (?) *morrisi* Cockerell[11] from the Jurassic or Cretaceous Ondai Sair formation of Mongolia. All of these are based upon specimens preserved as impressions and hence not showing structural details, and it is perhaps needless to say that there is no basis for supposing any relationship to the genus *Phyllocladus* which the name might be considered to imply.

In a recent publication[12] devoted to the Upper Cretaceous floras of Alaska Hollick describes and figures what he calls a "bract, phyllode or stipule" under the name of *Phyllocladites dubiosus*, which may or may not be related to what I have called *Drepanolepis reniformis* It is a single, detached, and

[2] THOMAS, H S, Phil Trans Roy Soc London B 213· 299–363 1925.

[3] THOMAS, H H, Ann Bot 45: 647–672. 1931

[4] VELENOVSKY, J, *Vergleichende Morphologie der Pflanzen*, Teil 3, 1910.

[5] VUILLEMIN, P, *Les Anomalies végétales* (Paris, 1926)

[6] EAMES, A J, Am Jour Bot 18: 147–188 1931

[7] NATHORST, A G, Kgl Svenska Vetens-Akad Handl, Band 30: No 1, 21, 71, *pl* 1. *figs* 16, 17; pl 3, *figs* 33–37 1897

[8] HEER, O, Fl Foss Arct, Band 4· pt 1 47 pl 9, fig 17 (lower right) 1877.

[9] NATHORST, A G, Op cit 43 *pl* 6, *figs* 24–26 1897

[10] HEER, O, Op cit, Band 3. ab 2 124 pl 35 *figs* 17, 18 1874 Idem, Band 4: 50 1877

[11] COCKERELL, T D A, Am. Mus Nat Hist Bull 51. 144, tf 6, *pl* 2, *figs*. 10, 11. 1924

[12] HOLLICK, A, U S Geol Survey Prof Paper 159 52 *pl* 2, *fig* 9 1930

apparently a foliaceous organ, veined somewhat like the outer coat in *Drepanolepis reniformis*, but very much larger (about 4 times) and flat, thinner and more delicately veined I very much doubt any relationship to either *Drepanolepis*, or to what Heer and Cockerell called *Phyllocladites*.

The question of the age of the Alaska material can not be definitely settled. The associated remains are specifically undetermined forms of *Sequoia*, *Podozamites*, *Pterophyllum* and *Sagenopteris*, together with scales and broken fish bones. All the plants belong to long-lived genera the species of which are not precisely determinable, and indicate an age somewhere between middle Jurassic and middle Cretaceous. One of the two *Podozamites* (the larger) appears to be identical with what Lesquereux called *Irites alaskana* from the Cape Lisburne region of Alaska, and which Fontaine referred to *Nageiopsis*, but which I decided did not belong to that genus when I revised it in 1911. The smaller *Podozamites* is much like the Siberian Jurassic form which Heer called *Podozamites eichwaldi* Schimper, but this similarity lacks precise age significance since similar forms under the same or other names occur at a number of Mesozoic horizons. As I interpret the inconclusive evidence as to age it appears more likely to have been late Jurassic rather than early Cretaceous.

In conclusion it should perhaps be mentioned that Thomas, in the papers previously cited, regards *Sagenopteris* as the foliage of the Caytoniales, and *Sagenopteris* is associated with the present fructifications that have been referred to *Drepanolepis*.

GEOLOGY.—*A revision of physical divisions of northern Alabama.*[1] W. D. JOHNSTON JR., U. S. Geological Survey. (Communicated by W. H. BRADLEY.)

In 1930 I proposed a detailed physiographic division of Northern Alabama,[2] based upon Fenneman's[3] classification, which covered that part of the State underlain by Paleozoic sedimentary and older crystalline rocks.

Since the publication of the Alabama paper some disagreement with

[1] Published by permission of the Director, U S. Geol Survey and the State Geologist of Alabama Received March 1, 1932.

[2] JOHNSTON, W D, JR, *Physical divisions of northern Alabama.* Alabama Geol. Survey, Bull 38, 1930

[3] FENNEMAN, N M, *Physiographic divisions of the United States*, (3d ed), Assoc Am. Geographers Annals, 18: no 4, 1928.

the classification used has been voiced by local geographers and Fenneman[4] has pointed out that the boundary line between the Interior Low Plateaus and the Appalachian Plateaus, adopted for Alabama in

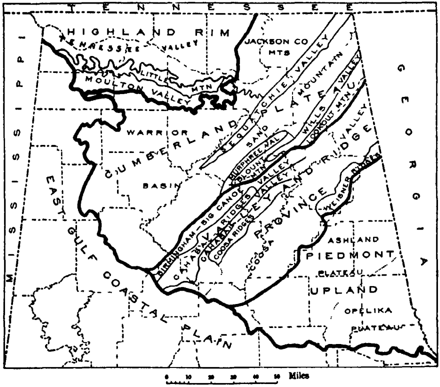


Fig 1 —Physical divisions of Northern Alabama

my former publication, is not in agreement with the stratigraphic marker used farther north. To meet these criticisms I offer the revised classification contained in Table 1 and the outline map, Figure 1.

[4] Personal communication

TABLE 1.—PHYSICAL DIVISIONS OF NORTHERN ALABAMA

Numbers in parentheses correspond with those used by Fenneman in Assc. Am. Geographers, Ann., vol. 18, No. 4, December, 1928

Major Division	Province	Section	District	Characteristics
Atlantic Plain	Coastal Plain	East Gulf Coastal Plain (3d)	Marginal	Old belted coastal plain
Appalachian Highlands	Piedmont Province	Piedmont Upland (4a)	Ashland Plateau	Maturely dissected peneplain on disordered crystalline rocks, strong relief
			Opelika Plateau	Submaturely dissected peneplain on disordered crystalline rocks, moderate relief
	Valley and Ridge Province	Tennessee section (6a)	Weisner Ridges	Maturely dissected monoclinal quartzite mountains, strong relief
			Coosa Valley	Mature plain with structural ridges of low relief
			Coosa Ridges	Synclinal maturely dissected ridges of moderate relief
			Cahaba Valley	Faulted monoclinal limestone valley of moderate relief
			Cahaba Ridges	Monoclinal maturely dissected ridges of moderate relief
			Birmingham-Big Canoe Valley	Faulted anticlinal limestone valley of moderate relief
	Appalachian Plateaus	Cumberland Plateau (8f)	Lookout Mountain	Submaturely dissected synclinal plateau of moderate relief
			Wills Valley	Anticlinal tripartite valley of moderate relief
			Sand Mountain	Submaturely dissected synclinal plateau of moderate relief
			Murphree Valley	Faulted anticlinal valley of moderate relief
			Blount Mountain	Submaturely dissected synclinal plateau of moderate relief

Appalachian Highlands. .	Appalachian Plateaus	Cumberland Plateau (8f)	Sequatchie Valley	Anticlinal tripartite valley of moderate relief
			Warrior Basin	Synclinal submaturely to maturely dissected plateau of moderate relief.
			Jackson County Mountains	Submaturely dissected plateau of strong relief
Interior Plains	Interior Low Plateaus	Highland Rim (11a)	Little Mountain	Submaturely dissected monoclinal ridge of moderate relief.
			Moulton Valley	Monoclinal limestone valley of low relief.
			Tennessee Valley	Young plateau of moderate relief.

BOTANY.—*Arizona plants. (Further additions to the recorded flora of the state, with notes on the characters and geographical distribution of these and others species.)*[1] THOMAS H. KEARNEY and GEORGE J. HARRISON, Bureau of Plant Industry.

A list of flowering plants and ferns believed to be new to the recorded flora of Arizona was published recently.[2] Collections, mostly in 1931, by Robert H. Peebles, Harold J. Fulton, and the writers, and by M French Gilman,[3] have brought to light several additional species, of which few seem to have been collected previously in Arizona and none, apparently, to have been recorded in any publication as occurring in that state. Six of them were not known to occur in the United States.

Using, with slight modification, the classification of ranges outside Arizona that was followed in the earlier paper (p. 65), the main geographical distributions of these 19 further additions to the recorded flora of Arizona are as follows

Pacific coast region (Washington to California)	1
California deserts (Colorado, Mojave)	2
Gulf of California region (Lower California, western Sonora)	1
Mexico (not confined to the preceding region) and southward	8
Kansas or Oklahoma to northern Mexico	2
Rocky Mountain region	1
California, eastern United States, tropics of both hemispheres	1
Old World (introduced species)	3

In the following list, species that so far as the writer knows have not been recorded previously as occurring in Arizona are indicated by a single asterisk. Double asterisks indicate that the plant is believed also to be new to the recorded flora of the United States.

The writers are much indebted to Dr. B. L. Robinson of the Gray Herbarium, Harvard University, and to Dr. John K. Small of the New York Botanical Garden for information in regard to the representation of these plants in the respective herbaria.

[1] Received March 6, 1932

[2] Kearney, Thomas H. Plants new to Arizona (An annotated list of species added to the recorded flora of the state or otherwise interesting) Journ Wash Acad Sci **21**: 63–80 1931 In explanation of the words "recorded flora" in this subtitle, it should be mentioned that no comprehensive list of Arizona plants has ever been published. If no statement of the occurrence of a given species in Arizona could be found in the various floras and monographs in which its range is stated, or if the range as given in these publications does not comprise Arizona, it was assumed to be new to the known flora of the state

[3] Plants designated by the large numbers (3592 to 8369, inclusive) were collected by one or more of the first group Mr Gilman's specimens are separately designated

CYPERACEAE

* ELEOCHARIS CARIBAEA (Rottb) Blake Collected on Rye Creek, near the eastern base of the Mazatzal Mountains, Gila County (no. 8369) There appears to have been no previous Arizona record of this widely distributed species, but the fact of its occurrence in southern California and in the southeastern United States presupposed its presence in Arizona.

LILIACEAE

CALOCHORTUS FLEXUOSUS Wats Collected on Rye Creek just east of the Mazatzal Mountains, Gila County, near the center of the state (no 7804). This collection extends the range considerably southward, the localities in Arizona where this species was previously known to occur being all in the northern part of the state (Grand Canyon, Peach Springs, Beaver Dam).

CLEISTOYUCCA BREVIFOLIA (Engelm) Rydb Several hundred good-sized "Joshua Trees" were observed in "bad lands" along the eastern slope of the Aquarius Mountains, near the border between Mohave and Yavapai counties (no. 7633). The occurrence of the plant at this locality had previously been noted by Fred Gibson of the Boyce Thompson Southwestern Arboretum. It is not, however, the southeastern limit of the species, M E Musgrave and S H. Hastings having found it several years ago at a locality some 30 miles farther south

ALLIONIACEAE

BOERHAAVIA MEGAPTERA Standley This well-marked species, known previously only from the vicinity of Tucson, was found at Topawa and at Sells in the Papago Indian Reservation, Pima County (nos 8027, 8032). The known range was thus extended about 50 miles westward

PORTULACACEAE

* CLAYTONIA ROSEA Rydb A collection in the Sierra Ancha, Gila County (no 7874) marks a considerable southward extension of the known range, Wyoming to Colorado and Utah.

SILENACEAE

* HERNIARIA CINEREA DC. This inconspicuous little plant, an introduction from the Old World, was collected near Casa Grande, Pinal County (no. 7518), and had been found previously by C R. Orcutt at Sentinel, in the southwestern part of Maricopa County.

SAXIFRAGACEAE

SAXIFRAGA RHOMBOIDEA Greene Collected in the Mazatzal Mountains and in the Sierra Ancha, Gila County (nos 7836, 7873). These localities extend the known range some 100 miles southward, the San Francisco Peaks apparently being the only locality in Arizona where the species had been collected previously

ROSACEAE

PRUNUS FASCICULATA (Torr) A Gray. Collected near Wickenburg, in the northwestern part of Maricopa County (no 7521) It is believed that this locality extends the known range of the "desert almond" in Arizona considerably southeastward

MIMOSACEAE

* VACHELLIA FARNESIANA (L.) Wight & Arnott (*Acacia farnesiana* Willd.). The occurrence in Arizona of the "huisache" seems not to have been recorded, although it was collected several years ago by David Griffiths at La Osa on the international boundary just east of the Baboquivari Mountains. Trees, some of which attain a height of 20 feet, have been found by W T Swingle and R. H Peebles about 20 miles north of the boundary, at the western base of the Baboquivari Mountains, Pima County.

MIMOSA LAXIFLORA Benth The occurrence of this Mexican shrub in southern Arizona was noted in an earlier paper (Kearney, ibid., p. 70). Observation during the past season showed it to be abundant near the base of Quijotoa Mountain, Pima County, (nos 7971, 8001) where it had been discovered by J Arthur Harris several years ago Some of the plants at that locality reach a height of more than 6 feet and are very attractive when in blossom The flowers, clustered in spikelike racemes, are deep purplish-pink at first, fading to nearly white, and have a delicate fragrance The plant grows on rocky slopes and along "washes," associated with *Anneslia eriophylla*, *Senegalia greggii* (*Acacia greggii*), *Cercidiopsis microphylla* (*Parkinsonia microphylla*), *Acalypha pringlei*, *Jatropha cardiophylla*, *Simmondsia californica*, *Carnegeia gigantea*, and several species of *Opuntia*

CAESALPINIACEAE

** GRIMALDIA ABSUS (L) Britton & Rose (*Cassia absus* L) Found at two stations near "Montezuma's Cave," high up on the western slope of the Baboquivari Mountains, Pima County (*Gilman*, nos 212 and 234) At one of the stations the plants grew on a ridge of decomposed granite This is believed to be the first collection of this interesting little annual in Arizona and in the United States The species is widely distributed in tropical America, but there are no specimens in the U S National Herbarium from farther north in Mexico than southern Sinaloa and the states of Jalisco, Morelos, and Vera Cruz If the plant is really adventive from the Old World, as is supposed, its occurrence in a locality so remote from ordinary lines of communication as the Baboquivari Mountains is most remarkable

FABACEAE

SOPHORA ARIZONICA Wats This handsome shrub, with dark green, somewhat shiny leaves and large Wisteria-colored flowers, was found growing on rocky hills and along "washes" some 20 miles southeast of Kingman, Mohave County (no 7623). The species has a restricted distribution and has seldom been collected, but it was fairly abundant at the locality mentioned Its beauty makes it as worthy of cultivation as are some of its better known congeners.

PAROSELA LUMHOLTZII (Robinson & Fernald) Vail. This well-marked species, described from specimens obtained by C V. Hartman at Los Pinitos, Sonora, has been recorded as occurring in Arizona, having been collected near Tucson by Herbert Brown, but apparently it is of rare occurrence in the state. It was collected in 1931 at the base of Baboquivari Peak, Pima County (*Gilman*, no. 241)

SPHINCTOSPERMUM CONSTRICTUM (Wats.) Rose. A collection of this plant on the western slope of the Baboquivari Mountains, Pima County, extends the known range of the species in Arizona some 40 miles to the west (*Gilman*, no. 121).

* ASTRAGALUS AGNINUS Jepson (*Cystium agninum* Rydb) A handsome milkvetch with showy, reddish-violet flowers, collected in 1927 near the north end of the Gila Mountains in Yuma County, where it occurs abundantly in loose sandy soil (nos 3592, 5029). This species having been known previously only from the western edge of the Colorado Desert, in California, another plant of that region is added to the recorded flora of Arizona Professor Jepson wrote to Dr W R Maxon on November 27, 1931, confirming the identification and pointing out only two minor differences between the California and Arizona specimens, the former having the leaflets more deeply notched at apex and the pods more arcuate The second difference, as Professor Jepson suggests, may be due to the more mature condition of the fruits in the California specimens

* PHASEOLUS ATROPURPUREUS DC Collected at a rather high elevation in Fresnal Canyon on the western slope of the Baboquivari Mountains, Pima County (*Gilman*, no 166) Mr Gilman describes it as growing in the midst of shrubs that support the stems, which are several feet long This appears to be the first collection in Arizona,[4] the previously known range of the species being from southern New Mexico and southern Texas to Mexico and Central America Gilman's specimens are thinner-leafed and less sericeous and have more obtuse leaflets than most of the Mexican and Central American specimens

EUPHORBIACEAE

CROTON SONORAE Torr The occurrence of this plant, previously known only from Mexico, in the western part of Pinal County, Arizona, was recorded in an earlier publication (Kearney, ibid , p 72) During the past season it was collected at Quijotoa and Topawa in the Papago Indian Reservation, Pima County (nos 7769, 8006, 8026) At the latter locality it grows abundantly on a rocky hill, the shrubs attaining a height and spread of about 4 feet and having stems one-quarter to one-third inch in diameter at base. The form collected at Quijotoa has exceptionally narrow leaves

DITAXIS BRANDEGEI (Millsp) Rose & Standl The presence of this species in the Gila Mountains, Yuma County, was reported in an earlier publication (Kearney, ibid , p 72) During the past season a plant 6 feet high was observed at the same locality by Robert H Peebles (no 7704) Hence, at its northern limit the species attains about the maximum height that it reaches in Lower California and Sonora[5]

ACALYPHA PRINGLEI Wats The discovery of this Mexican shrub at Quijotoa, Pima County, Arizona, by J Arthur Harris, was recorded previously (p 72). During the past season it was observed growing abundantly at the same locality, along washes and on low rocky hills (nos 7999, 8000) It is conspicuous during the season of summer rains, because of the vivid green of its foliage. The plants attain a height of only 2 or 3 feet at this locality, and show considerable variation in the size of the leaves and in length and color of the staminate inflorescences The scales of the latter usually

[4] Specimens collected by T E Wilcox (no 70) near Ft Huachuca, Cochise County, which are presumably the ones listed under *P atropurpureus* by Britton and Kearney (Trans N Y. Acad Sci **14**: 34 1894) belong to *P macropoides* Gray

[5] Standley, Paul C Trees and Shrubs of Mexico Contr U S Nat Herb **23**: 621 1923

are red or reddish. The stamens are white, and the stigmas pale lavender. Some of the associated species are listed in the note on *Mimosa laxiflora*.

RHAMNACEAE

COLUBRINA CALIFORNICA Johnston The collection of this species by Peebles and Harrison in 1926 in Fish Creek Canyon, Maricopa County (Kearney, ibid, p 73) was not the first in Arizona, Gilman having found it at the same locality several years earlier His specimens were identified by J. J. Thornber as "*Colubrina* sp "

MALVACEAE

** ABUTILON THURBERI A Gray. This species, apparently known previously only from the type collection by George Thurber at Magdalena, Sonora, was collected in a canyon on the western side of the Baboquivari Mountains, Pima County, apparently for the first time in the United States (*Gilman*, no 35). Gilman's specimen, without fruit, corresponds closely in vegetative and flower characters with the type in the Gray Herbarium, except that the stems are nearly glabrous, whereas in the type they are sparsely villous with long hairs

HORSFORDIA ALATA (Wats) A Gray The writer, in the earlier paper mentioned (p 73), erroneously described the petals as of a "pale violet blue" color R H Peebles calls attention to the fact that the color of the fresh petals is pale purplish-pink, although they become bluish with age

** ANODA CRENATIFLORA Ortega. The finding, in the Chiricahua Mountains, of flowering specimens identified doubtfully as of this species was reported previously (p 73) During the past season, mature specimens were obtained at Tumacacori, in the valley of the Santa Cruz River (no 8146), and the characters of the very distinctive fruits remove all doubt as to the identification The presence of this species in Arizona and in the United States, therefore, is definitely established

HIBISCUS BISEPTUS Wats George J Harrison has noted two characters distinguishing this *Hibiscus* from the somewhat similar *H coulteri* Harvey, that seem not to have been recorded previously One is the persistence of the fruits after maturity in *H. biseptus*, whereas in *H coulteri* the pedicel disarticulates at base The other character is that in *H biseptus* the flattened faces of the seeds are devoid of hairs in the center, the hairless area amounting to one-third to one-half the surface of the seed, whereas in *H coulteri* the hairs are evenly distributed over the whole surface *Hibiscus coulteri* is a much woodier plant than *H biseptus*

APIACEAE

* FOENICULUM VULGARE L. The common fennel of the Old World, although naturalized abundantly in California and sparingly so elsewhere in the United States, seems not to have been reported hitherto as occurring in Arizona A form with exceptionally short segments of the leaves was collected in the Mule Mountains near Bisbee, Cochise County (no 8284).

PYROLACEAE

** CHIMAPHILA DASYSTEMMA Torr This species, known previously only from the mountains of Mexico, was found in the Santa Catalina Mountains, Pima County, at an elevation of about 8,000 feet, growing in clefts of rocks among yellow pines (no 8100) It flowers in August in this locality and is apparently rare, diligent search having discovered only three individuals.

C. dasystemma bears a marked resemblance to *C maculata* (L.) Pursh, of the eastern United States, and is regarded by Standley as not specifically distinct from the latter.[6] If this view be correct, the range of *C maculata* shows a remarkable interruption, similar to that of *Crotalaria sagittalis* and *Clitoria mariana* (Kearney, ibid., pp. 70 and 71).

APOCYNACEAE

AMSONIA KEARNEYANA Woodson This species, known so far only from the western side of the Baboquivari Mountains in Pima County, Arizona, was regarded by Woodson[7] as representing "a natural hybrid between the subgenera *Sphinctosiphon* and *Articularia*." This conclusion was based partly upon the deformed fruits and sterile seeds of the only fruiting specimen available to Woodson when he wrote his description Specimens since collected by R. H. Peebles (no. 7933) at or near the type locality have, however, perfectly formed fruits and viable seeds. Mr Peebles demonstrated this by a germination test in which about 80 per cent of the seeds sprouted In view of this finding, of the exceptional isolation of the habitat, and of the apparent absence of other species of *Amsonia* in the Baboquivari region, there seems to be little to support the hypothesis of hybrid origin

CUSCUTACEAE

** CUSCUTA TUBERCULATA Brandegee This very well-marked species of dodder, known previously only from the southern part of Lower California and from northwestern Sonora (*Pringle*) has been discovered recently in southern Arizona It occurs rather abundantly along a sandy wash just north of the Gila River, in Pinal County (no 8193), and has been collected also near Sells, Pima County (no 8038) The Arizona specimens correspond closely with the type in the herbarium of the University of California, which was collected by T. S. Brandegee on Santa Margarita Island, Lower California In Arizona, and usually in Lower California, the species is parasitic on species of *Boerhaavia*

CONVOLVULACEAE

* IPOMAEA HETEROPHYLLA Ortega. The collection near Tombstone, Cochise County, in 1929, of a plant identified as *I lindheimeri* Gray was reported in an earlier paper (Kearney, ibid , p. 75). Specimens that are similar, except in having the leaf-lobes narrower and more attenuate at both ends, were collected in Fresnal Canyon on the western side of the Baboquivari Mountains, Pima County (*Gilman*, no 109) All of the Arizona specimens have shorter peduncles and shorter and broader sepals than specimens of *I lindheimeri* from Texas and New Mexico As the species of this group are defined by House,[8] the broad bases of the sepals of the Arizona specimens indicate that they belong to *I heterophylla*, although the corolla is longer and narrower than in most of the Mexican specimens so identified in the U. S National Herbarium *I heterophylla* seems not to have been reported previously as occurring in Arizona Its range, as given by House, is western Texas and northern Mexico.

[6] Standley, Paul C. Trees and Shrubs of Mexico Contr U S Nat Herb **23**. 1090 1924

[7] Woodson, Robert E , Jr Studies in the Apocynaceae, III. A monograph of the genus *Amsonia*. Ann Missouri Bot Garden **15**: 379–434 1928 (p 416).

[8] House, Homer D North American species of the genus *Ipomaea*. Ann N Y Acad Sci **18**: 181–263 1908

HYDROPHYLLACEAE

* HYDROPHYLLUM OCCIDENTALE A. Gray. The collection of this waterleaf in the Mazatzal Mountains, Gila County (no. 7829), affords apparently the first record of its occurrence in Arizona and extends the known range of the species (Washington to California, Nevada, and Utah) considerably to the southeast.

BORAGINACEAE

* PLAGIOBOTHRYS JONESII Gray. Ivan M. Johnston has identified as of this species a specimen collected near Sacaton, Pinal County, a few miles south of the Gila River (no 7514), and remarks (in letter to T. H. Kearney): "Known only from at most a score of collections in the eastern part of the Mojave Desert of California I do not know of a [previous] collection actually from Arizona. Your collection is a big and most interesting eastern extension of this rare and very distinct species"

MENTHACEAE

* SCUTELLARIA DRUMMONDII Benth. The range of this skullcap, as given by Leonard[9] is Oklahoma, New Mexico, Texas, and northeastern Mexico. It occurs also in Arizona, where it was collected along Salt River by Smart, and near Bisbee by Goodding A third collection, made recently near Roosevelt, Gila County (no. 7778), has been identified by Leonard as *S. drummondii*.

SOLANACEAE

SOLANUM DEFLEXUM Greenman. Collections in southern Arizona of a small-flowered, short-pedicelled form of this chiefly Mexican plant were reported previously (Kearney, ibid, p. 77). A specimen that is normal in size of the corolla and length of the pedicels was collected recently at Tumacacori, Santa Cruz County (no. 8147).

** SOLANUM LUMHOLTZIANUM Bartlett. This well-marked species, belonging to the section *Androcera* (Buffalo burs), was found near Patagonia, Santa Cruz County (no 8185) The plant seems to have been known previously only from the type collection by C V. Hartman at La Tinaja, Sonora. The Arizona specimen corresponds closely with the type in the Gray Herbarium and with Bartlett's excellent description, except that the corolla is yellow, not purple, as doubtfully characterized by that author. The narrow, pointed leaf-lobes and the pubescence are very characteristic. Harrison noted in the field that the larger spines of the fruit are black with yellow tips, the small spines of the fruit are greenish white, and the spines on the upper side of the branches are black at base.

* DATURA STRAMONIUM L Specimens collected at a roadside near the head of Tonto Creek, Gila County (no. 8364), afford what is presumably the first record of occurrence of the common jimson weed in Arizona, unless a specimen in the U. S National Herbarium, with leaves only, collected in the Chiricahua Mountains by J C. Blumer (no 2267), belongs to this species.

SCROPHULARIACEAE

MAURANDYA ACERIFOLIA Pennell. The range of this apparently rare and very local species has been extended ten miles westward of the type locality (Fish Creek Canyon, Maricopa County) to Surprise Canyon, just south of the

[9] Leonard, Emery C. The North American species of *Scutellaria*. Contr. U. S. Nat Herb. 22: 703–748 1927 (p. 730).

Salt River (no. 7774). As at the type locality, the plants were growing in crevices of partly shaded cliffs.

CUCURBITACEAE

* CYCLANTHERA DISSECTA (T. & G.) Arn. This plant, apparently rare in Arizona, was collected in canyons on the western side of the Baboquivari Mountains, Pima County (*Gilman*, no 198) The only previous collection in Arizona of which the writer is aware was in the Santa Rita Mountains, Pima County, by David Griffiths and J J Thornber Gilman's collection therefore extends the known range of the species about 45 miles westward The recorded distribution of *C dissecta* is Kansas to Louisiana, Texas, and northern Mexico. As the species apparently does not occur in New Mexico, this seems to be another case of interrupted range

ASTERACEAE[10]

ERIGERON PRINGLEI A Gray. Collected on the rim of Pueblo Canyon in the Sierra Ancha, Gila County (no 7884). Apparently this species was known previously only from the type collection by Pringle on cliffs of Mt Wrightson, in the Santa Rita Mountains In the type collection the lower leaves are laciniate-pinnatifid, whereas in no 7884 they are very narrowly linear-oblanceolate and entire Otherwise the specimens correspond exactly and undoubtedly represent the same species

SENECIO QUERCETORUM Greene Specimens were obtained on Oak Creek, Coconino County (no. 7160), and on the rim of Pueblo Canyon, in the Sierra Ancha, Gila County (no 7889). Previously known only from two collections by Rusby, on Oak Creek, the type collection (no 672), and at an unspecified locality in Arizona (no. 175), the latter being the type of *S macropus* Greenm Dr. Greenman, who has referred *S macropus* to *S quercetorum*, described the plant as perennial, as Dr. Greene had done, but Fulton's excellent and complete specimen in the U S National Herbarium (no 7160) has a root that is obviously annual or, at most, biennial.

SCIENTIFIC NOTES AND NEWS

Dr J BARTELS, who, as a research associate of the Carnegie Institution of Washington, has been engaged on the theoretical interpretation of the accumulated observational date at the Department of Terrestrial Magnetism in Washington, D. C, having completed his year's leave of absence from Germany, has returned to his position in the Forstliche Hochschule in Eberswalde.

The thirteenth annual meetings of the American Geophysical Union and its sections will be held April 28 and 29, 1932, at the National Academy-Research Council Building, 2101 Constitution Avenue, Washington, D C

Meetings of scientific societies will be held in Washington as follows: National Academy of Sciences, April 25 and 26; American Physical Society, April 28 to 30; American Section of International Union of Scientific Radiotelegraphy, April 29; American Meterological Society, May 2.

A bill authorizing an appropriation of $30,000 to defray the expenses of participation by the United States Government in the Second Polar Year Program, August 1, 1932, to August 31, 1933, has been passed by Congress and signed by the President.

[10] Identifications and notes communicated by Dr S. F. Blake.

E. P. KILLIP, Associate Curator of Plants, U. S. National Museum, who left Washington early in February for study in European herbaria, reports very satisfactory results at Berlin. After a month at the Museum d'Histoire Naturelle, Paris, where he now is, Mr. KILLIP will leave for several weeks' work at the Royal Botanic Gardens, Kew, and the British Museum (Natural History), returning to Washington early in May. The work upon which he is engaged, aside from completing monographic studies of several large groups, consists in the identification of extensive series of specimens from the northern Andean region of South America. This material consists partly of specimens collected upon at least a dozen major expeditions, and partly of specimens that have come in during recent years from a large number of institutions and individuals in South America.

HORACE G. RICHARDS has been promoted from Aid to Assistant Curator in the Division of Mollusks, U. S. National Museum

On Wednesday evening, March 30, in the auditorium of the National Museum, a lecture under the auspices of the Smithsonian Institution on "Plant Records of the Rocks" was presented by ALBERT CHARLES SEWARD, D Sc, F R S, Master of Downing and Professor of Botany, Cambridge University.

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CHEMISTRY.—*Unhydrated solute element ions.*[1] L. H. Flint, Bureau of Plant Industry. (Communicated by G. N. Collins.)

In a consideration of the hydration of some solute element-ions as comprised in the first two papers of the present series[2] attention has been directed to a group of electrolytes whose components behaved rather consistently as hydrated ions in aqueous solution For example, the chlorine ion, Cl^-, in solutions of the electrolytes KCl, NaCl, LiCl, $MgCl_2$, $CaCl_2$, $AlCl_3$, $CrCl_3$, $CuCl_2$, $SrCl_2$ and $CdCl_2$ as involved in measurements of electrical conductivity, seemed uniformly subject to characterization as having a hydration of seven water molecules, all the other ions also having the respective hydration values assigned them under the initial assumptions regarding hydration designated in Table 1, and interpreted through the assumption of change in weight with ionization. At this point we may examine some electrolytes which appear to give rise to unhydrated ions in aqueous solution.

Hydrochloric Acid, HCl. The relatively high velocity of the hydrogen ion, H^+, has frequently led to the conclusion that this ion is characteristically not hydrated. Various measurements of solution phenomena, moreover, have seemed to corroborate this conclusion. It will be of interest, therefore, to examine some observed relative velocities with respect to the assumptions of hydration and weight-change embodied in Table 1, and the above conclusion.

The ion-conductance of the ions K^+ and H^+ at 18°C. as cited by Creighton and Fink[3] and derived from observed electrical conductivities through the use of transference measurements, are as follows:

[1] Received March 28, 1932.

[2] This Journal 22: 97–119 and 211–217, 1932 Herein are given the tables to which reference is made in this paper

[3] Creighton, H. J. and Fink, C. J. *Electrochemistry.* Wiley and Sons, Vol I, 1924, p. 134.

$K^+ = 64.5$, $H^+ = 313$. Referring now to Table 1 of the first paper we may derive the assigned value for the velocity of the ion K^+, considered as hydrated, in the following manner:

$K = 38$, $K^+ = 40 + 3\ H_2O\ (3 \times 18) = 40 + 54 = 94$ (weight of hydrated ion, column 7). The velocity value corresponding with this weight is 1031 (column 8).

We may now consider the above ion-conductance values as relative velocities, since each ion carries the same charge, and determine the corresponding relative velocity of the H^+ ion on the tabulated scale by solving for x in the ratio

64.5 :	313 ::	1031 :	x
obs. Vel.K^+	Obs. Vel.H^+	calc. Vel.K^+	(hydrated)

$x = 5000.$

Determining the indicated relative velocity of the H^+ ion as 5000 we note that there is no such figure comprised within the series of column eight, representing velocities of hydrated ions, but that the figure corresponds precisely with the figure representing the velocity of the hydrogen ion, H^+, considered as unhydrated, given in column four and derived as follows:

$H = 2$, $H^+ = 4$ *with no hydration*, $V_1 = 5000$

The agreement is in substantiation of the above-noted conclusion.

We may now proceed to compare the observed relative specific molecular conductivity of HCl at 1.0 molecular concentration with that which would be expected under the assumption that the H^+ ion was not hydrated

$H = 2$, $H^+ = 4$,	with no hydration, ionic wt.	= 4
$Cl = 34$, $Cl^- = 32$,	with 7 H_2O, ionic wt. hyd.	= 158
summation wt.		= 162

$1000 - 162 = 838$, or 83.8% solvent.

Observed specific molecular electrical conductivities of HCl may be cited as follows:[4] 1.0 mol. = 199.85, "0" mol. = 236.92; $199.85 \div 236.92 = .844$, or 84.4%.

The order of agreement is in further substantiation of the conclusion that the H^+ ion is characteristically not hydrated in aqueous solution.

Rubidium Chloride, RbCl. The summation weight suggested by Table 1 as representing the solute present in a solution of RbCl at 1.0 molecular concentration on the weight basis if the rubidium ion, Rb^+, does not hydrate may be calculated as follows:

[4] Jones, H. C. Carn. Inst. Wash. Pub. No. 180, 1913, p. 80

Rb = 74, Rb^+ = 76; with no hydration, ionic wt. = 76
Cl = 34, Cl^- = 32; with 7 H_2O, mol. wt. hydrated = 158
108 = mol wt., anhyd summation weight = 234

From this value the relative weight of solvent may be derived as
1000 − 234 = 766, or 76.6%.

The relative specific molecular electrical conductivity of RbCl at 1.0 molecular concentration may be derived from observed values at 18°C. as follows:[5] RbCl at 001 molecular concentration = 130.1; at 1.0 molecular concentration = 102; 102 ÷ 130 1 = .784, Rel. sp. mol. conductivity = 78.4%.

The apparent specific molecular conductivity at "zero" concentration may be presumed to be somewhat higher than that at .001 molecular concentration, with the relative value at 1.0 mol. somewhat lower. The agreement between the value calculated on the above basis (76.6%) and the observed value (78.4%) calculated from a somewhat low base, may be considered as evidence that the Rb^+ ion in aqueous solutions of RbCl is not hydrated.

Caesium Chloride, CsCl The summation weight suggested by Table 1 as representing the solute present in a solution of CsCl at 1 0 molecular concentration on the weight basis if the Cs^+ ion does not hydrate may be calculated as follows·

Cs = 110, Cs^+ = 112; with no hydration, ionic wt. = 112
Cl = 34, Cl^- = 32; with 7 H_2O mol wt. hydrated = 158
summation wt. = 270

From this value the relative weight of solvent may be derived as
1000 − 270 = 730, or 73.0% solvent.

The relative specific molecular electrical conductivity of CsCl at 1.0 molecular concentration and 18°C. may be derived from observed values as follows·[6]

CsCl, 1.0 mol. conc = 98.8, .0005 mol. conc. = 131 05, 98.8 ÷ 131.05 = .754. Relative specific molecular conductivity = 75.4%.

The apparent specific molecular conductivity at "zero" concentration may be presumed to be somewhat higher than that observed at .0005 mol. Under the circumstances the order of agreement between the calculated value (73 0%) and the value as observed (75.4%), appears to constitute evidence that the Cs^+ ion in aqueous solutions of CsCl is not hydrated.

Although in the electrolytes HCl, RbCl and CsCl the positive ion

[5] Values cited are from Int Crit Tables, Vol 6, p 234
[6] Previous citation

has been indicated as unhydrated, there appears to be no reason why the absence of hydration may not characterize the negative ion. On such an assumption we may examine further as follows.

Potassium Bromide, KBr. The summation weight representing the solute present in a solution of potassium bromide, KBr, at 1.0 molecular concentration on the weight basis if the bromine ion, Br^-, does not hydrate may be calculated as follows:

K = 38, K^+ = 40, with 3 H_2O, mol. wt. hydrated	=	94
Br = 70, Br^- = 68, with no hydration, ionic weight	=	68
summation wt	=	162

From this value the relative weight of solvent present may be derived as 1000 − 162 = 838, or 83 8% solvent.

The relative specific molecular conductivity of a 1.0 molecular solution of KBr, may be approximated from observed values at 0°C. as follows.[7] .5 molecular concentration = 65 82; .000976 molecular concentration = 79 23; 65.82 − 79.23 = .831. Relative specific molecular conductivity at .5 molecular concentration = 83 1%. The corresponding value for 1.0 molecular concentration is not given in the reference cited, and would be somewhat less,—yet the indicated order of agreement appears to constitute evidence that the Br^- ion in aqueous solutions of KBr is not hydrated.

Potassium Iodide, KI. The summation weight representing the solute present in a solution of potassium iodide, KI, at 1.0 molecular concentration on the weight basis if the iodine ion, I^-, does not hydrate may be calculated as follows.

K = 38, K^+ = 40, with 3 H_2O, mol. wt. hydrated	=	94
I = 106, I^- = 104, with no hydration, ionic wt.	=	104
summation wt.	=	198

From this value the relative weight of solvent may be derived as 1000 − 198 = 802, or 80.2% solvent.

The relative specific molecular conductivity of a 1.0 molecular solution of KI may be derived from observed values at 18°C. as follows·[8] 1.0 molecular concentration = 96.8; .0005 molecular concentration = 121.2, 96 8 ÷ 121.2 = .799. Relative specific molecular conductivity = 79.9%.

The agreement between the predicted value (80.2%) and the observed value (79.9%) is of an order to constitute evidence that the I^- ion in aqueous solutions of KI is not hydrated.

[7] Jones, H C Carn Inst Wash Pub No 170, 1912, p 21.

[8] Jones, H C and Caldwell, B P Am. Chem. Journ , May 1901.

The consideration of electrical conductivity measurements of aqueous solutions of HCl, RbCl, CsCl, KBr, and KI suggests that there may be hydrated ions in association with unhydrated ions, and that the unhydrated state may characterize either the positively-charged or the negatively-charged component.

It will now be of interest to note that a similar examination of the relative specific molecular conductivities of the electrolytes cadmium bromide, $CdBr_2$, and cadmium iodide, CdI_2, leads to the conclusion that in aqueous solutions of these salts all ions are hydrated. Yet we have heretofore noted that in association with potassium as KBr and KI the ions Br^- and I^- were indicated as not hydrated. Under the circumstances it appears that the presence or absence of the hydration of the Br^- and I^- ions may be a matter of association. Since by the precepts of the present inquiry hydration conditions the velocity of an ion it follows that we have come into variance with the Kohlrausch Law of the Independent Migration of Solute Ions, which holds velocity as independent of association

In connection with the consideration of the hydration characteristics of inorganic and organic molecular ions in subsequent papers of this series it will be of interest to note from time to time further evidence that association may condition the presence or absence of hydration. Within the limits of a specified state, hydrated or unhydrated, the Law of Kohlrausch has been shown in this and in the foregoing papers to be applicable in substantial measure to concentrated solutions. Yet with the accession of additional evidence that the two states, hydrated and unhydrated, may characterize the ions of the same elements in different electrolytes, it would appear that the law would fail as a correct description of velocity relationships.

CHEMISTRY.—*Lignin-like complexes in fungi.*[1] CHARLES THOM and MAX PHILLIPS, Bureau of Chemistry and Soils.

Recent papers dealing with the decomposition of plant residues (Waksman and associates)[2] point to the lignins as decomposing more slowly than other plant constituents, hence as tending to accumulate as a result of the rotting of plant materials. The abundance of these lignin-like complexes in soil organic matter is noted as confirmatory evidence. The accumulation of the remains of soil microörganisms is also indicated as one source of these slowly decomposing substances.

[1] Received April 1, 1932

[2] Summarized with bibliographic notes by Waksman, S A *Principles of Soil Microbiology* Ed 2. Chapter 24 1932

Additional information as to lignin-supplying organisms becomes therefore of interest.

Every field student of the fungi is familiar with the abundance of black and brown (dematiaceous) species upon the surfaces of decaying vegetation. They give a dirty black brown color to plant remains in the field and the fence corner during the moist portions of the year. Many of them are less familiar with the fact that these organisms predominate only in the presence of air and light. They are not commonly found actively vegetating entirely below the surface of the soil. In connection with our studies of decaying crop residues, certain analyses have been made in the Bureau of Chemistry and Soils, which may be worthy of record.

Four of these species common on the soil and on decomposing plant remains, were grown upon Czapek's solution which presents sucrose as the only source of carbon. These were incubated until thick masses of dark mycelium were developed. The cultures were then filtered through sintered glass Jena crucibles, washed with water, dried at 105°C. The dry material was extracted with a 1.1 alcohol-benzene solution, dried and analyzed for lignin by the fuming hydrochloric acid method (J. Assoc. Off. Agric. Chemists **15**; 124. 1932). The percentage of lignin was calculated on the oven-dry (105°C.) material.

The results of the analyses have been tabulated as follows:

Species	Per cent Lignin
(1) *Alternaria* sp	17 25
(2) *Epicoccum* sp	20 30
(3) *Sclerotinia libertiana* (with sclerotia present)	7 85
(4) *Cladosporium* sp	29 27

The amount of lignin found was sufficiently striking to suggest the analysis of certain bracket fungi.

Species	Per cent Lignin
Hydnum caput-ursi (pure white)	2 65
Polyporus sulphureus (sulphur yellow)	3 40
Trametes pini (deep brown)	54 08
Fomes igniarius (almost black)	36 95

There is a marked contrast between the pure white *Hydnum* and the sulphur yellow *Polyporus* on the one side and the deep brown *Trametes* and almost black *Fomes*, on the other. Confirmatory analyses of other cultures and samples support the view that the dark brown, leathery, black and carbonaceous masses produced by whole groups of fungi are high in organic complexes of a lignin-like character, whereas the colorless or light colored fungi have little lignin-supplying power.

A possible relationship to soil organic matter might be suggested by the predominance of black and brown molds on vegetation decaying at and just above the surface of the soil as such decomposition occurs under natural or so-called "virgin" soil conditions. Brown and black forms produce very little growth in material plowed under, hence play little part where clean cultivation involves covering all crop residues with several inches of earth.

CONCLUSION

In the analyses reported (a), the brown walled molds such as *Cladosporium* and *Alternaria* contain high percentages of lignin-like substances (such as 17.25 to 29 27% in dry matter) upon culture media presenting sucrose as a sole source of carbon. (b) Brown walled bracket fungi such as *Trametes pini* and *Fomes igniarius* contain even higher percentages of these "lignins." (c) The light colored bracket fungi showed correspondingly little lignin-like substance.

PALEONTOLOGY.—*New species of fossil Raninidae from Oregon.*[1] MARY J. RATHBUN, U. S. National Museum.

From time to time Dr Hubert G. Schenck of Stanford University has given to the National Museum various crustaceans from the Tertiary of Oregon. Among them are four new Raninidae which are here described and will be incorporated in Schenck's report on the region.

Raninoides oregonensis, new species

Seemingly related to *R. eugenensis* Rathbun[2] from the Oligocene of Lane County. Anterior portion of carapace lacking Carapace broadest at anterior ⅖, broader than in *eugenensis*, but like that species, convex from side to side and sloping gradually downward on the median line from the anterior to the posterior end Surface covered with minute granules not visible to the naked eye and with the tips rubbed off, appearing like punctae. A lateral spine near anterior fifth and directed obliquely forward is broken off near base Length (estimated) 38, greatest width behind spines 32, posterior width 16 mm

Type-locality—Near Dallas, Polk County, Oregon, limestone formation, Eocene Cat No 371922, U S N M

Lyreidus alseanus, new species

The specimen, encased in a nodule, was originally longer and flatter than at present. The carapace is cracked across the widest part and again across

[1] Published with the permission of the Secretary of the Smithsonian Institution Received February 25, 1932

[2] Bull 138, U S Nat Mus, 1926, p 96, pl 24, fig 4.

the front half, the broken edges overlapping each other and at the middle pushed upward There is also a longitudinal break at the left of the median line. Front narrow, widening a little at extremity; at the left 2 rounded lobes separated by a subrectangular sinus and succeeded by a rounded sinus,

Fig 1 (Left) *Raninoides oregonensis* Dorsal view of carapace of holotype, showing lateral spine, x 1-1/2

Fig 2 (Right) *Raninoides oregonensis* Same specimen from the right side, showing part of lower surface, x 1-1/2

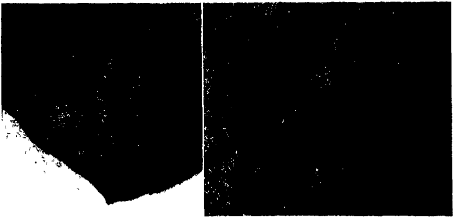
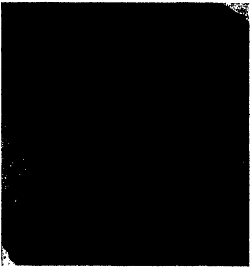


Fig 3 (Left) *Lyreidus alseanus* Dorsal view of an inner layer of carapace of holotype, cracked and out of shape, x nearly 2

Fig 4 (Right) *Lyreidus alseanus* Lower side of upper layer of carapace of same specimen, x nearly 2.

all of which occupy half or nearly half the front Carapace widening rapidly from rostrum to lateral angle, in front of which on the right side there is a small knoblike tooth, longer than broad, curving forward and away from the antero-lateral margin, just outside this tooth is the impression of another.



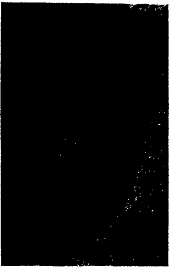
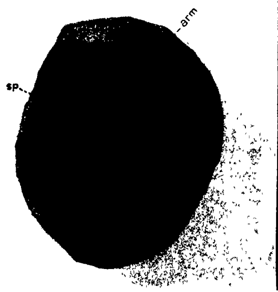


Fig. 5. (Left) *Eumorphocorystes schencki*. Dorsal view of carapace of holotype showing antero-lateral spine, x 1-1/2.

Fig. 6. (Right) *Eumorphocorystes schencki*. Left profile of same carapace, x 1-1/2.



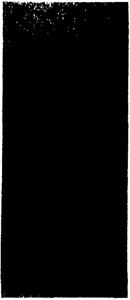


Fig. 7. (Left) *Eumorphocorystes leucosiae*. Dorsal view of carapace of holotype showing origin of lateral spine and portion of right arm, x 2.

Fig. 8. (Right) *Eumorphocorystes leucosiae*. Left side of holotype showing chela and fragments of legs, x 2.

Behind the lateral spine the angle of the carapace is rounded and the postlateral margins are blunt and converge rapidly toward the posterior end. Exposed dorsal surface with some fine granulation near antero-lateral border; this is, however, not the true outer layer which is shown in the opposing half of the nodule (Fig 4), its under surface is exposed and is covered with large, smooth, almost contiguous granules, which in the reverse or upper layer must appear as so many pits At the lateral angle on what is the true right side there is a tooth pointing directly outward; this is a stout, blunt tooth similar to the one described above but straighter; one or two of the teeth or spines indicated may belong to the carpus of the cheliped.

Apparent length of carapace 24.6, width 23 7 mm

Type-locality—Tuffaceous sandstone on S side of Alsea Bay about ⅛ mile E. of B M 12, and ¼ mile E of Waldport, Lincoln Co, Oregon, Sec. 20, T 13 S., R. 11 W Lower Oligocene. Sept. 14, 1926. Hubert G. Schenck. Cat. No. 371901, U. S N. M.

Eumorphocorystes schencki, new species

Two carapaces, very convex from front to back, more so from side to side Shape, broad oval, width 40 mm, length about 45. Front narrow, about ⅛ as wide as carapace excluding spines, details obscure. A spine at anterior third of lateral margin or about 15 mm behind margin of front; spine 6 7 mm long, tapering to a slender point and directed well outward. Behind the spines the side margins are parallel along the middle third. Posterior margin somewhat wider than anterior, and slightly convex Surface covered with large round pits, irregularly disposed, rarely in contact A blunt, longitudinal, median carina the length of the carapace, becoming widest between the crescentic, branchio-cardiac grooves.

Type-locality—Washington County, Oregon, near center of section 3, T. 2 N., R. 5 W, Beaver Creek road, Gales Creek to Timber, 3 miles S of Timber Keasey formation, "*Cardium weaveri*" zone, Oligocene, Holman #27 John T Holman and H G. Schenck collectors, 1931. Cat. No 371921, U. S. N M.

Eumorphocorystes (?) leucosiae, new species

Carapace subglobular, little longer than broad, posterior margin ½ as wide as carapace, subtruncate, a little concave at middle, front about ⅛ as wide as carapace, middle third of lateral margins subparallel. Surface covered with small pits, interspaces rough with fine granules, two longitudinal furrows through middle of carapace, near together at posterior third, diverging at either end, more so anteriorly, intermediate surface convex; branchial regions swollen. Lateral spine indicated at anterior third of lateral margin. Left chela uncovered, palm elongate, widening distally, half as wide as superior length, bluntly carinate above and armed with four spines below. Fingers strongly deflexed, tips crossing, prehensile edges wavy, meeting, outer edges carinate, carinae set off by a furrow Fragment of arm rough like carapace.

Approximate length of type carapace 28 6, width 23 mm. A larger specimen is 30.3 x 26 2 mm.

Has much the appearance of a Leucosiid.

Type-locality—Polk County, Oregon, center of E. line of N. W quarter of Section 21, T 6 S, R 6 W.; very prominent cut in bank on E. side of Mill Creek, visible from road from Buell to Sheridan. Formation probably Keasey, "*Cardium weaveri*" zone, Oligocene. Holman #1. John T. Holman collector, 1931. Cat No 371902, U. S. N. M.

ZOOLOGY.—*Nematosis of a grass of the genus* Cyanodon *caused by a new nema of the genus* Tylenchus *Bast.*[1] N. A. COBB, Bureau of Plant Industry.

Tylenchus[2] *tumefaciens* n. sp. $\frac{0.8}{1.2}$ $\frac{3.6}{2.6}$ $\frac{?}{?}$ $\frac{^{60}\text{'}88+}{4.5}$ $\frac{96.8}{1.9}$ 1.4mm The posterior swelling of the oesophagus in this species seems to be somewhat set off from the intestine The *reflexed portion of the ovary* contains the ova in about three ranges or rows, and appears one-third as wide as the corresponding portion of the body, and *has a length about twice as great as that of the neck.* At the blind end of the ovary there is a special single cell, taking up the full width, and having a distinct, clear, spherical nucleus, nearly one-third as wide as the cell. The nucleus contains a fairly granular spherical nucleolus half as wide as the nucleus itself The immediately adjacent ova differ in having larger granular nuclei with somewhat larger but similar nucleoli In this reflexed portion of the ovary the ova as they pass cephalad increase slightly in size, but do not exhibit much detail in structure. Passing around the flexure, the ova slowly begin to change in structure, and by the time they are opposite the blind end of the ovary, the nuclei begin to show chromosomes

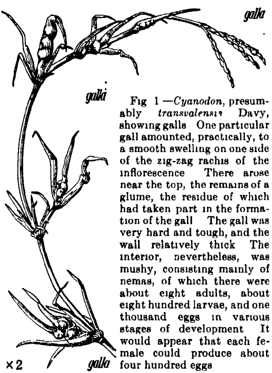


Fig 1 —*Cyanodon*, presumably *transvalensis* Davy, showing galls One particular gall amounted, practically, to a smooth swelling on one side of the zig-zag rachis of the inflorescence There arose near the top, the remains of a glume, the residue of which had taken part in the formation of the gall The gall was very hard and tough, and the wall relatively thick The interior, nevertheless, was mushy, consisting mainly of nemas, of which there were about eight adults, about eight hundred larvae, and one thousand eggs in various stages of development It would appear that each female could produce about four hundred eggs

The large transverse *vulva spans the ventral fourth,* or even the third of the body, and is so massive that sometimes the *part of the body behind is bent dorsad at an obtuse angle* The acute tail is nearly straight, slightly convex-conoid, it may be even slightly dorsally arcuate. *Anus inconspicuous* *The massive uterus,* occupying most of the corresponding body cavity, *usually contains but one egg* The spherical spermatozoa, packed in the uterus so as to be more or less polyhedral, are about one-fourth as wide as the body of the female, they are finally granular

[1] Received April 1, 1932

[2] The genus name *Tylenchus* is used here instead of a recently discovered prior synonym because of the author's confidence that if and when the attention of the International Commission on Zoological Nomenclature is called to the matter it will decide that far greater confusion and inconvenience will be caused by following the rule of priority in this case than in not following it, and will abrogate the rule, as it has power to do in such cases.

and contain a nucleus half as wide as themselves, which is more granular, and which contains a distinct, highly refractive, spherical, structureless-looking nucleolus about one-third to one-fourth as wide as the nucleus itself. Notwithstanding the size of the sperms, a fertilized female may contain hundreds of them. The matured ova are rather coarsely granular, are pressed one against another in the ovary and sometimes appear wider than they are long, and in some parts apparently are packed more densely than double file. *At the vulva the body of the female suddenly diminishes* in diameter, so that in passing one-half body length caudad the diameter diminishes fifty per cent

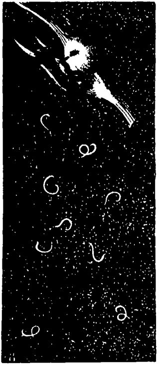


Fig 2 —A gall from the tissues of the base of a leaf sheath A portion of the sheath tissue pulled away nearly intact The inner tissues of the sheath had produced the wall of the tumor The mushy interior was very distinct from the wall, and occupied a distinct cavity, in which the nemas lay loose, free to move about The nine adult nemas and the numerous eggs and larvae shown were taken from another gall of *the same size* Thus the picture shows a gall and a corresponding nemic population

The transverse striae of the cuticle, measured just behind the vulva, are one micron apart.

The inconspicuous, posterior, bulbous half of the spear, which accords with conditions found in some other species of *Tylenchus*, suggests that published illustrations and descriptions of a considerable number of Tylenchi may ultimately have to be revised for the reason that the more obvious anterior half of the spear has been inadvertently described as if it were the entire organ. Sometimes the posterior portion of the onchium of a Triplonch may, even in life, be very inconspicuous and become nearly invisible when mounted in glycerine or glycerine jelly,—still more so in balsam. Under such deceptive conditions the real length of the spear is sometimes indicated by the length of the contractile fibers passing from the labial framework to the tribulbous base of the spear, as in the present case. See Fig 3

$$\frac{0.8}{1.1}\qquad\frac{5.3}{2.0}\qquad\frac{(?)11}{(?)2.6}\qquad\frac{M}{3.2}\qquad\frac{94}{2.6}\;1.2\text{mm}$$

The vas deferens and ejaculatory duct occupy the greater portion of the body cavity toward the posterior extremity of the male. The testis is strongly developed and at its *bent blind end* is slightly expanded, measuring there about one-half the corresponding body diameter At first the primary spermatocytes contain large subspherical nuclei with distinct nucleoli, the nuclei being one-fifth to one-sixth as wide as the corresponding portion of the body.

Habitat: Found in small galls on the above-ground parts of the grass *Cyanodon sp ?*,—presumably *C transvalensis* (*Fide* A S. Hitchcock). The plants are killed by the parasite, the grass dying off in patches. Sent by Dr. Potgetier, from Pretoria, South Africa.

Diagnosis. **Tylenchus tumefaciens** n. sp. *Tylenchus* Bastian, formed and dimensioned as indicated in the formulae, illustrations and italicized text.

This nematosis[3] has recently come to notice in a number of Bradley grass lawns in Johannesburg and Pretoria. It seems probable that it occurs widely. Usually it is first noticed in small patches. A close examination of a diseased plant discloses greenish or reddish lumps up to the size of a canary seed, occurring on the stems and leaves,—less often in the inflorescence. Breaking these tiny galls, one discovers with a magnifying glass that the interior of the gall is inhabited by nemas, the cause of the disease. An infestation of one Pretoria lawn was traced to another lawn, from which some planting grass had been taken.

The tiny galls, or tumors, on the grass are so inconspicuous that they might easily escape notice and the disease be unwittingly spread. Once present, the disease accumulates, and after a year or more, patches of ailing grass become apparent. The pest is believed to have been present in Pretoria for some years. The abandonment of one variety of lawn grass[4] is probably due to this disease.

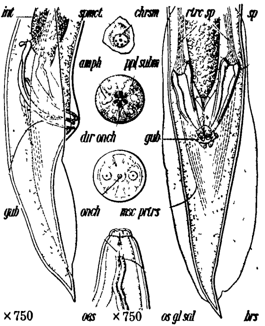


Fig 3—Lateral and ventral views of the tail end of the same male specimen of *Tylenchus tumefaciens* n sp Below, head of the same, dorsal view The upper small figure is of a spermatocyte whose nucleus shows chromosomes Of the two middle figures, the upper is a front view of the head, showing the four submedian papillae and the two duplex amphids, while immediately below is an optical section at the base of the lip region, each magnified about fifteen hundred diameters

Precautions. 1. Prompt burning off of diseased patches after spraying with inflammable liquid,—i.e. kill the tops, not the roots. 2 Avoidance of seed and cuttings from infested areas 3. Unusually careful inspection of grass cuttings used as sets. 4. Recleaning of suspected grass seed.

[3] Abstract from *South African Gardening and Country Life* **15**, Jan , 1925

[4] Variety "Red Quick Grass," presumably a species of *Cyanodon* N. A C

ZOOLOGY.—*The life in the ocean from a biochemical point of view.*[1]
PAUL S. GALTSOFF, United States Bureau of Fisheries.

For many years the interest of zoologists engaged in a study of marine life centered around morphological and taxonomic problems. Numerous expeditions organized by every civilized country of the world have collected an enormous amount of zoological and botanical material and have accumulated many data concerning the distribution of animals and plants in relation to the physical and chemical conditions in the sea Many efforts were made to take a census of the total population of the ocean and to determine its fertility. For that purpose thousands of samples of plankton and of the forms living on the bottom were collected and studied. The reports of these investigations fill thousands of pages and are at present available for further scientific analysis Unfortunately in many instances when attempts were made to correlate the biological data with physical and chemical observations, the results were conflicting and difficult to interpret. It seems that quite often the broader problems of oceanic biology were buried under the vast material accumulated by the expeditions, and that the scientific research was not in proportion to the effort and money spent.

During the last ten years there has been a revival of interest in oceanographical research in this country, which culminated in the establishment of a number of new institutions for the study of the ocean. The question naturally arises as to what are the outstanding problems in modern oceanography which justify both the expenditure of large sums of money and of human effort It is quite obvious that the continuation of purely taxonomic and descriptive investigations so extensively carried out since the time of the *Challenger's* expedition will not help in unravelling the complicated relations that exist between the inhabitants of the sea and their environment; neither will they determine the factors that control their propagation and distribution in the ocean.

One of the main results of previous studies was a recognition of the fact that the population of the sea is subject to regular cyclic changes. Certain forms appear during definite seasons, reach the maximum of their abundance, then decline and give place to another group of forms, which pass through a similar cycle. Inasmuch as these changes are

[1] Received February 9, 1932 Third paper in a symposium, *Major problems of modern oceanographic research*, at the meeting of the American Association for the Advancement of Science, at Pasadena, Calif, June 17, 1931

very pronounced in planktonic forms, like diatoms or dinoflagellates, most of the investigations concerning the periodicity of life cycles refer to these organisms. However, cyclic changes occur also in nektonic and benthonic forms. Many speculative theories were advanced to explain this phenomenon. Real progress was made during the last decade by the investigators of the Plymouth Station (England) who have demonstrated that cyclic changes are accompanied by profound changes in the chemical composition of sea water, and that the decrease or increase in the amount of various salts (phosphates, nitrates, silicates) can be correlated with the abundance or scarcity of various planktonic forms. Thus the morphological and taxonomic investigations in oceanography gradually give place to physiological and biochemical research.

The propagation of organisms in the ocean is dependent on the presence of various elements which are necessary for the building up of their bodies. Lack of a necessary element or its presence in a state not available for a given organism becomes a factor preventing its growth and propagation. Thus, the minimum concentration of any substance indispensable for a given organism becomes a factor limiting the propagation of this particular species This principle established by Liebig and known as the "law of a minimum" is applicable both to land and marine forms.

There exists a great variety of physical and chemical factors that may interfere with the growth of living forms or check their propagation. On the other hand a temporary absence of limiting factors may result in an extremely rapid propagation of the organism which, in a short time, may fill up all the space available for its growth. Such a phenomenon, quite common in unicellular and planktonic forms, has been very appropriately called by Vernadsky "an explosion of life" It is often observed in fresh water ponds or in enclosed bays. The best example of it in the sea is found in a sudden propagation of a diatom *Aulacodiscus kettoni* along the Copalis beach in the state of Washington, where under certain conditions described by Becking and others[2] it develops in a nearly pure culture. As a result of this rapid development a large amount of phosphates, nitrates, silicates, and other salts, are withdrawn from the sea water, accumulated in the bodies of the diatoms and deposited in a thick layer on the bottom. The process continues for several days, then ceases, to recur again after a

[2] Becking, L B, Tolman, C F, McMillin, H C, Field, J, and Hashimoto, Tadaichi. Economic Geology **22**: 356–368 1927.

period of inactivity which may last for several weeks. The development of *Aulacodiscus* is a good example of a dynamic equilibrium that exists between the living organism and the surrounding medium. The diatom withdraws from the solution and accumulates in its body several elements that were present in the water, producing considerable change in the chemical composition of the latter which, in turn, becomes a factor limiting its further growth and propagation. There is no doubt that every organism behaves in a similar way differing only in the velocity and type of chemical reactions involved in its activity.

The biochemical rôle of organisms in the ocean can be understood by comparing the chemical composition of sea water with that of the

TABLE I.—THE AVERAGE COMPOSITION OF SEA WATER (ACCORDING TO W I. VERNADSKY)

Elements	Per cent	Elements	Per cent
O	85 80	Fe	$1\ 5 \times 10^{-4}$
H	10 67	Ag	1×10^{-4}
Cl	2 07	P	$n \times 10^{-4}$ ($n \times 10^{-5}$)
Na	1 14	Ar	5×10^{-5}
Mg	$1\ 4 \times 10^{-1}$	I	$n \times 10^{-5}$ (n 3)
S	9×10^{-2}	F	3×10^{-5}
Ca	5×10^{-2}	B	$n \times 10^{-5}$
K	4×10^{-2}	Cu	$n \times 10^{-5}$ (n = 1 or 2)
C	$3\ 5 \times 10^{-3}$	Li	6×10^{-6} (8×10^{-6})
Br	2×10^{-3}	Au	$1\ 2 \times 10^{-6}$
N	$1\ 6 \times 10^{-3}$	As	1×10^{-6}
Rb	$1\ 5 \times 10^{-3}$	Th	1×10^{-6}
Si	$n \times 10^{-4}$ (n = 3?)	Zn	$n \times 10^{-7}$ (n 1 2?)
		Ra	$n\ 1\ 4 \times 10^{-12}$

living matter. In this attempt we meet with an unexpected difficulty. Our knowledge of the chemical composition of sea water is very inadequate. Most of the analyses deal with the salts that are found in relatively large concentrations, and neglect the elements occurring in very small amounts. Yet, as it will be shown later, the physiological rôle of the latter may be of great importance, and their presence in the water may be prerequisite for the propagation and development of certain forms. The most complete summary of the present state of our knowledge of the chemical composition of the sea water is given by Vernadsky[3] in Table I.

[3] Vernadsky, W. Rev Gen d Sc Pures et Appliques, **35**: 5–13 1924 *La Geochimie.* 1924 Libr F Alcan Paris.

An examination of Table I shows that our knowledge of the composition of the sea water is far from being complete, and that for a number of elements the quantitative data are only approximate. The table does not contain data for Al, Pb, Ti, Sr, and V which were found in certain marine organisms and probably occur also in sea water. On the other hand, one must bear in mind that the investigations of Atkins, Nathanson, Harvey and others have demonstrated that the concentrations of nitrates, phosphates, and silicates, do not remain constant, but are subject to considerable fluctuations, depending on the activity of the organisms. Thus, the old conception of the constancy of the chemical composition of sea water, established by Forchhammer in 1850–1860, and up to present time generally accepted in oceanographical literature, should be considered with certain reservations We know that not only does the salinity (i e the total amount of salts in solution) vary in different localities, but that there exist considerable fluctuations in the proportion of certain salts. Although the absolute figures may appear insignificant (for instance the phosphate content of the water in the Faeroe-Shetland Channel varies from a few to forty milligrams per cubic meter), they may have a strong effect on the population of the sea.

A comparison between the chemical constituents of the sea water and those of the living matter convinces us that many of the elements that occur in the sea in a highly dispersed state are accumulated in the bodies of the living forms. Unfortunately, whereas the chemical composition of the sea water is not well known, our knowledge of the chemical composition of the living matter is even more fragmentary According to Vinogradov[4] less than one-half of one percent of all the living species have been subjected to elementary chemical analysis, which in most of the cases dealt with only a few elements. Analyses of the whole body of the organisms are also nearly absent, the chemical data usually referring to the composition of the separate organs, skeleton, or blood.

Excepting the well known work of Butschli[5] and a general review of Aron[6] the information regarding the chemical composition of various organisms is available mainly from the mineralogical literature and refers almost exclusively to the skeletons and shells. The most impor-

[4] Vinogradov, A "Priroda" No 3, pp 230–254 1931

[5] Bütschli, O Zool Anz 30: 784 1906. K Gesell Wiss Göttingen, Math-Physik Kl 6, Band 6 1908.

[6] Aron, H. Oppenheimer Handbuck d Biochemie, I, p 62 1909.

tant contributions are those of Cayeux,[7] Samoilov,[8] Vernadsky and Clarke and Wheeler.[9] These investigations closely connect the problems of marine biology with geology and mineralogy, and stress the rôle of living forms in the origin of various minerals of sedimentary rocks.

A survey of available literature on the subject reveals that the same elements that are found in the sea water occur also in the organisms, although in entirely different concentrations. Some of them as for instance calcium, sulphur, potassium, carbon, nitrogen, silicon, iron, phosphorus, iodine, fluorine, boron, copper, zinc, manganese, vanadium, lead, and titanium are concentrated in the living matter while others, as for example sodium, chlorine, bromine, magnesium, occur in it in concentrations approximately equal to that in the sea water.

TABLE II.—ACCUMULATION OF ELEMENTS BY LIVING MATTER

Elements	Concentration Times
S	100
P	1000
Si	1000
K	10
Fe	100
Zn	10,000
Cu	100
I	100
As	100
B	10
F	10

Vernadsky gives estimates (Table 2) of the minimum concentration of various elements in the bodies of marine forms, as compared with their concentration in the sea water. The figures do not refer to any particular organism but are the averages for the living matter in general.

Although it is known that Al, Mn, Pb, Ti, and V are accumulated by the organisms, it is impossible at present to express their concentrations in definite figures.

Marine plants and animals can be grouped on the basis of the ele-

[7] Cayeux, L. *Introduction à l'étude pétrographique des roches sédimentaires.* Paris. 1916

[8] Samoilov, J. Mineral Magazine **18**: 87. 1917. Comp. Rend. d. XIII, Congr. Geolog. Intern. 1924. Centr., of Mineral. **19**, 594. 1924.

[9] Clarke, F. W., and Wheeler, W. G. Proc. Nat. Acad. Sc. **1**, p. 262. 1915. U. S. Geol. Surv. Prof. Paper 124. 1922

ments that are accumulated by their bodies. The space of this paper does not permit us to give a complete list of them, and we have to restrict our discussion to a few outstanding examples We begin with the accumulation of calcium. According to Clarke[10] the annual deposition of calcium in the sea amounts to 1400 million tons. The greatest rôle in the process of withdrawing lime from solution and depositing it on the bottom should be attributed not to the vertebrates, corals, molluscs or other larger organisms with calcareous skeleton, but to the smallest Protozoa belonging to the group of Coccolithophoridae. Their importance in the deposition of calcium was suggested by Lohman,[11] who found that every twenty-four hours one-third of the population of these forms dies and sinks to the bottom, where it takes part in the formation of calcareous deposits.

The skeletons of marine organisms accumulating calcium are built either of calcium carbonate (aragonite and calcite $CaCO_3$; dolomite, $CaCO_3MgCO_3$) or calcium phosphate ($3Ca_3(PO_4)_2CaCO$) and apatite $(CaF)Ca_4P_3O_{12}$. A study of the chemical composition of shells of Brachiopods and Echinoderms by Clarke and Wheeler (1915, 1922) reveals an interesting fact that there exists considerable difference in the composition of the skeleton of various forms belonging to the same class. According to their work, the Brachiopods fall into two distinct groups; the shells of one consisting mainly of calcium carbonate with little organic matter, while the shells of the other group are formed mainly of calcium phosphate with much organic matter. The first group is represented by species of *Terebratula*, *Crania*, *Waldheimia*, and others, while the second group comprises *Lingula*, *Discinisca*, and *Glottidia*. The two groups are physiologically quite dissimilar, the chemical reactions involved in building the shells being of two different orders Such a distinction, said Clarke, "ought to be significant to biologists and it is for them to determine what it means." Unfortunately, the biologists know very little about the reactions involved in building of shells and the significance of the difference just described is not understood.

Evidence that difference in the chemical composition of animals can be correlated with their habitat, and possibly with the temperature of the water in which they live, is found in another paper of Clarke and Kamm[12] dealing with the analyses of Echinoderm shells. Different species of starfishes show, according to this paper, a progressive enrich-

[10] Clarke, F W *Data of Geochemistry* 1924 Washington

[11] Lohmann, H Intern Rev Ges Hydrol 1: 309-323 1908

[12] Clarke, F. W, and Kamm, R M Proc Nat Acad Sci 3: 401 1917.

ment in magnesia following an increase in the temperature of their habitat. In the specimens from high latitudes or from deep water the proportion of magnesium carbonate ranges from 7 to 10 percent, while those from tropical waters contain from 11 to over 14 percent. We have at present no explanation to offer for the existence of such differences. These examples show very plainly that even within one taxonomic group the organisms differ from each other not only morphologically but also in the chemical composition of their bodies.

The cycle of silicon and the accumulation of this element by diatoms, radiolaria, and siliceous sponges is another oceanographical problem which attracted a great deal of attention. The rôle of the diatoms in the life of the ocean is well known to everybody acquainted with oceanographical problems. However, the question concerning the source of silicon, which is used by diatoms for building their tests remains unsolved. Murray has expressed a view that the amount of silicon found in solution in the sea water is insufficient to supply the demands of the diatoms and that the latter obtain this element by splitting the clay particles suspended in water Later on (Murray and Irvine[13]), he was able to show experimentally that *Navicula* can live in water containing no silicon in solution, but only in suspension. These findings were corroborated by Vernadsky[14] who observed the formation of aluminum hydrates in the culture of *Nitzchia* grown together with the unidentified bacteria in a medium which contained silicon only in a form of suspended clay particles. It is known that the minerals, like mica, epidote, nephelene and others, transform into kaolin without changing their kaolin nucleus which has the following composition—$H_2Al_2Si_2O_8H_2O$. The kaolin nucleus is a very stable chemical compound which withstands heating up to 1000°C., but can be split by treatment with concentrated H_2SO_4 at 100°C. Yet it is apparently decomposed by the action of the organisms. The question is still open whether this is due to the activity of the diatoms or should be attributed to the bacteria that were grown in the diatom cultures.

We may briefly mention other organisms which are accumulators of various elements It is a well known fact that iodine, which occurs in the sea in minute amounts, is accumulated by algae, gorgonacea, and sponges. In the latter it is found in the form of an albuminoid ($C_{86}H_{87}I\ N_{10}S_2O_2$). The amount of iodine in these organisms varies

[13] Murray, J , and Irvine, R Proc R Soc Edinb 18: 245 1891

[14] Vernadsky, W Comptes Rend Acad Sci , Paris, 450–452 1922. Rev. Gen. d. Sc Pures et Appliques, 34: 42 1923

from 1.7 percent of dry substance (*Gorgonia acerosa*) to 7.8 in *Gorgonia clavellina*. Small amounts of iodine were observed in various molluscs and fishes. The physiological significance of this element in the metabolism of these forms is unknown.

The presence of copper in the bodies of marine invertebrates has been an object of numerous investigations. It is well known that copper enters into the composition of a respiratory pigment, haemocyanin, which in several forms (lobster, shrimps, crawfish and others) plays the rôle of haemoglobin. Copper was found also in a Coelenterate, *Anthea cereus* (2.35 mg. per 100 gr. wet weight); in Echinoderms, *Stichopus regalis*, (2.83 mg.), *Asterias rubens*, (2.45 mg), in various molluscs, and in sardines, herring and salmon.

In the lamellibranchs that can accumulate copper in considerable amounts the metal occurs not as a protein compound but in a simpler form. It has been known for many years that in certain sections of the Atlantic coast, and around the British Isles, the oysters become green. The green pigment was associated with an increase in their copper content. It was thought that the pigment might be haemocyanin or at least similar to haemocyanin in chemical composition. Recent investigations by Galtsoff and Whipple[15] have shown that the green pigment of oysters is not haemocyanin or copper proteinate of any kind. It passes through a collodion membrane which holds back congo red and is not precipitated by sodium sulphate. Although its chemical nature remains undetermined, it has been found that the pigment exists in a highly dissociated state and is of a small molecular size.

The amount of copper accumulated by oysters is very variable. According to the determinations of Galtsoff and Whipple the copper content in normal oysters from Cape Cod varies from 0.16 to 0 24 mg. per oyster or from 8 21 to 13.77 mg. per 100 grams of dry weight. The amount of copper concentrated in green oysters from Long Island Sound varied from 1.24 to 5.12 mg per oyster or from 121.71 to 271.91 mg. per 100 grams of dry weight. On the average there was about 2.5 mg. of pure copper in every green oyster. Knowing the copper content of green oysters and the extent of oyster beds affected by greening, it is possible to estimate the amount of copper which oysters withdraw annually from the water. There are at least 10,000 acres of oyster bottoms in Long Island Sound which produce green oysters. Assuming that oysters become green in one year, and that there are one

[15] Galtsoff, P S, and Whipple, D V Bull Bur Fisheries, 46: 489–508 1931

thousand bushels to each acre of ground, and that three hundred oysters make up one bushel, we arrive at the conclusion that the oysters of Long Island Sound deposit in their bodies about 7.5 metric tons of pure copper annually.

Space does not permit us to discuss the accumulation and possible rôle of strontium, found in the Radiolaria; barium, which was discovered as crystals of barium sulphate in the protoplasm of *Xenophyophora*, vanadium, discovered in the blood of Ascidians in which it apparently plays a rôle in the respiratory exchange of gases; and other elements (Zn, Mn, K, S, Fe, P, Al, etc.) which are accumulated by various forms.

After the death of the organism the accumulated material is deposited on the bottom and enters into new reactions resulting in the formation of various minerals found in the sedimentary rocks. Here the field of biology ends and we enter into realm of geology and mineralogy. Although the boundary line is indistinct, and the processes of accumulation of elements in living matter and their further rôle in the formation of minerals on the bottom of the sea are but the different phases of one cycle, we shall not trespass in this field, foreign to biologists, but return to the living organisms and consider how their lives may be affected by slight changes in the chemical composition of the sea water. This field of research scarcely has been touched by scientific investigations and our knowledge is therefore very limited. Interesting progress along this line was made, however, by recent work on oysters.

These molluscs inhabit the inshore waters where the environment is subject to periodical changes caused by the tides. Due to the discharge of river waters the salinity of the inshore area fluctuates quite widely. Consequently, the organisms living in this environment must adapt themselves to considerable fluctuations in osmotic pressure and to changes in the chemical composition of the water concurrent with the different stages of tide. It has been found by Prytherch[16] that the copper content of the water in Long Island Sound fluctuates between 0.1 part per million at high water and about 0.5 part per million at low tide. The increase in copper at low tide is due to the discharge of fresh water by the rivers. On the other hand, it has been observed in laboratory experiments that copper salts have a peculiar effect on oyster larvae, inducing their attachment to the substratum and initiating their metamorphosis. Under experimental conditions

[16] Prytherch, H F Science, 73: 429–431. 1931.

the full grown larvae responded to copper treatment very readily and with great precision. By employing this method it was possible for the first time to obtain a complete photographic record of their behavior during setting and metamorphosis. That the peculiar effect was due to copper, but not to other elements which are brought in by rivers, was corroborated by numerous experiments with various salts of Fe, Pb, Zn, Mn, St, Ba, Al, Ni, Co, which gave no positive results. The anions are apparently not involved in this reaction because different copper salts (carbonates, sulphates and chlorides) had exactly the same effect.

The results of the laboratory experiments were corroborated by field observation. Prytherch observed the intensity of setting of oyster larvae by counting at brief intervals the number of larvae attached to a plate that had been placed in the bay. The intensity of setting increases with the increase in copper content of the water, the latter reaching its maximum at low tide. The two curves run parallel and are undoubtedly significant. These observations explain the peculiarity in the distribution of the natural oyster beds which occur mainly in the mouths of rivers Apparently the river water, having a higher copper content, supplies the necessary stimulus that initiates the "setting" reaction of the full grown oyster larvae. The result is that the best setting areas are found on bottoms affected by fresh water. We are, however, ignorant as to the biochemical reaction involved in this phenomenon. It is extremely interesting that the organism reacts in a very distinct manner to slight fluctuations in the content of this metal, ranging only from 0.1 to 0.5 part per million. Greater concentrations of copper ions are distinctly injurious to the larvae causing the disintegration of their tissues and death. We are dealing here with an extremely well adjusted and sensitive mechanism which responds to slight changes in the environment.

The fluctuation in the concentration of other elements due to tidal changes may also have a pronounced effect on the activity of the organism. Hopkins, working in the Gulf of Mexico, has noticed considerable fluctuations in the potassium salts. Also in his work on the chemical sensitivity of the oyster[17] he found that the potassium ion has greater stimulating power in comparison with other metals. It is quite probable that fluctuations in the chemical composition of the environment may have a profound effect on all marine forms, and that they greatly influence their feeding, growth, and propagation.

[17] Hopkins A. E Journ. Exp Zool 61: 13-29 1932

Further research along this line, which is now under way, will probably throw more light on the relation between the organism and its environment. It is quite permissible to suppose that eventually the explanation of so-called lunar cycles in the behavior of various marine forms will be found in the periodical chemical changes which occur in the environment and in the organisms themselves.

So far we have been dealing with the inorganic constituents of sea water. But sea water contains also various products of metabolism given off by the organisms. Although they occur only periodically and cannot be regarded as constituents of the sea water, yet some of them play an important rôle in propagation of marine forms by stimulating the shedding of their eggs and sperm. The chemical composition of these substances is wholly unknown but one of their typical characteristics is the specificity of their action. The presence of these specific agents has been demonstrated by the experiments with *Nereis* (Lillie and Just[18]), sea urchins (Fox[19]), and both edible and pearl oysters (Galstoff[20]). The latter experiments have shown that the female oysters discharge a certain substance which has a specific effect on the males of the same species causing an immediate discharge of sperm. The substance is soluble in sea water and withstands boiling for ten minutes. The sperm discharged by the males contains an active principle which initiates in a female a complex reaction consisting of rhythmical contractions of the adductor muscle, contraction of the mantle, and discharge of eggs. The specific agent of sperm suspension is insoluble in sea water and is very unstable, being destroyed by heating for fifteen minutes at 60°C This active principle of the sperm is effective only under definite thermic conditions. In the *Ostrea virginica*, the reaction occurs only if the temperature of the water is above 20°C. The specificity of the reaction was established by experiments with various molluscs, *Mytilus*, *Mya* and with different species of oysters (*O. cucullata*, *virginica* and *sandwichensis*). In case of *O. virginica* and *O. cucullata*, it has been found by the author that the males can be induced to spawn only by the eggs or egg water of the same species and fail to respond to the addition of foreign eggs.

It is interesting that in spite of this specificity, the reaction can be provoked also by an increase in temperature. The author's latest experiments, carried out in 1931, show that ripe males and females of *O. virginica* can be induced to spawn by taking them from water of 19°C. and keeping them at a temperature above 24.5°C. Below

[18] Lillie, F R, and Just, E E Biol. Bull 24: 147-159 1913
[19] Fox, M Proc Cambr Phil Soc Biol Sc 1: 71-74. 1924
[20] Galtsoff, P S Proc Nat Acad Sc 16: 555-559 1930

24.5°C. the temperature alone is insufficient to induce spawning of the female, which, however, readily responds to the addition of sperm. From these observations an inference can be made that sperm plays the rôle of a "key" that unlocks a certain mechanism which in turn initiates in the female a chain of reactions and that the same results can be obtained also by a physical factor (increase in temperature). The reaction is, however, highly specific in the sense that under certain temperature conditions (between 20 and 24.5°C.) it appears to be provoked only by the sperm of the same species.

There is no doubt that the sexual reactions just described fall in the category of chemical stimulations, which play an important rôle in the life of marine organisms, especially of the sedentary forms like the oyster which possess no organs of vision, but have a well developed chemical sense, and are able to detect slight concentrations of various substances.

The few examples discussed in the present paper show very clearly that many problems of oceanic biology can be studied from a biochemical point of view. We may look upon an organism in the sea as part of a complex chemical cycle in which a given form is only one of the links in a long chain of cyclic reactions, or we may study it with the purpose of understanding the factors controlling its propagation, development, functioning of its body and peculiarities of its behavior. In all cases we are dealing with biochemical problems which can be attacked by an experimental method. We know that marine forms play a definite rôle in the chemical cycles of various elements occurring in sea water, and that on the other hand they are very delicately adjusted to their particular habitats. It is our hope that an understanding of their work and of the mechanism of their adjustment can be reached through biochemical and physiological studies which open up new fields of research and should lead to the solution of problems which the descriptive methods, so generally used in oceanography, were unable to solve.

ZOOLOGY.—*On a new Cyprinoid from South Dakota.*[1] SAMUEL F. HILDEBRAND, U. S. Bureau of Fisheries. (Communicated by WALDO L. SCHMITT.)

An apparently undescribed species of the genus *Hybognathus* occurs among a lot of cyprinoids submitted for identification by Dr. E. P. Churchill of the University of South Dakota. The writer takes pleas-

[1] Published by permission of the U S. Commissioner of Fisheries Received March 29, 1932

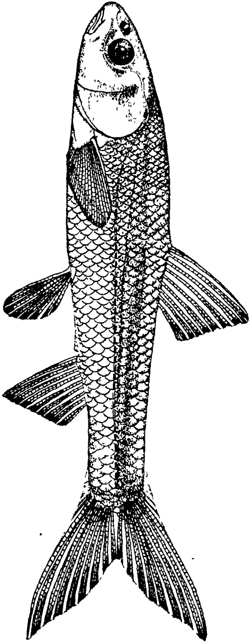


Fig 1 *Hybognathus churchilli* Total length, 71 mm. Drawn from the type by Louella E. Cable of the U. S Bureau of Fisheries.

ure in naming this fish for Doctor Churchill who collected the specimens and who has made an extensive study of the fishes of South Dakota.

Hybognathus churchilli sp nov.

Type No. 92248 U. S. National Museum, length 71 mm , Cheyenne River, S. D.

Description of the type.—Body very elongate and slender, not strongly compressed, about three-fourths as broad as deep at origin of dorsal, the greatest depth contained in length to base of caudal 5 2 times, the peduncle compressed, its depth 2.3 in head, head low and rather broad, 4 1 in length of body to base of caudal, its depth at middle of eyes 2 3 in its length to bony margin of opercle; interorbital moderately convex, 3.5 in head, eye small, 5 6 in head; snout moderately conical, projecting about half an eye's diameter beyond the mouth, its length 3.7 in head, mouth slightly oblique, the gape reaching almost opposite posterior nostril, scales small and thin, especially reduced in advance of dorsal, 41 oblique rows running upward and backward between upper anterior angle of gill opening and base of caudal, 6 complete rows between origin of dorsal and lateral line, 4 between origin of anal and lateral line, 20 oblique rows crossing the back in advance of dorsal; dorsal with 8 branched rays the longest rays a little shorter than head, none of them produced, the fin having no high lobe anteriorly, its origin slightly nearer tip of snout than base of caudal, the caudal deeply forked, the lobes pointed and of nearly equal length, anal with 8 branched rays, a little lower than dorsal, its origin below tips of the longest rays of the dorsal when deflexed, ventral fins smaller than the pectorals, inserted slightly behind the vertical from origin of dorsal, pectoral fins failing to reach base of ventrals by a distance equal to length of snout, 1 3 in head.

Color after preservation in formalin slightly brownish above, with dusky punctulations, paler below and without punctulations (the sides no doubt are silvery in life, although this no longer is evident), a dusky vertebral streak in advance of dorsal, a slight indication of a dusky lateral band, the fins unmarked. (Fig. 1.)

Variations.—The variations within the species, as far as shown by 10 paratypes, are not pronounced The following proportions and counts give the range within the specimens at hand Head 3 9 to 4.25, depth 4 9 to 5 6 in standard length; eye 5 0 to 5 75; snout 3 1 to 4 0, interorbital 2 7 to 3 5, depth of head at middle of eye 2 0 to 2 4, caudal peduncle 2 2 to 2 7 in head. D. 8, A. 7 or 8, scales 18 to 21 before dorsal, sometimes crowded, irregular and difficult to enumerate, 40 to 44 in lateral series, 6 complete rows above the lateral line and 4 below it, counted respectively at origin of dorsal and of anal. Pharyngeal teeth in 3 specimens examined 0,4–4,0, compressed and slightly hooked at tips Peritoneum jet black, intestine long and coiled. Origin of dorsal usually equidistant from tip of snout and base of caudal, occasionally slightly nearer the snout, the anterior rays of the dorsal sometimes somewhat produced, seldom sufficiently to make the fin falcate, ventral fins inserted under or slightly behind vertical from origin of dorsal.

Relationship —The present species apparently is more slender than others

of the genus, and the scales are small, being especially reduced in advance of dorsal. Comparing the present species with *H. nuchalis*, the other common local species, it is evident that the body is more slender (the range in depth in 7 specimens of *nuchalis* being 4.36 to 4.9); the eye is smaller, a difference which is most evident when specimens of the same size are compared, for example, in 3 specimens of *churchilli* all about 80 mm. long the eye is contained in the head respectively 5 5, 5 5 and 5.28 times, whereas in *nuchalis* in 3 specimens of about the same length the eye is contained in the head respectively 4.4, 3 85 and 4.3 times. The scales, especially in advance of the dorsal are larger, the range in 7 specimens of *nuchalis* being 14 to 15 in advance of dorsal, 35 to 38 in a lateral series, and 5 above the lateral line and 4 below it, counted respectively at the origin of the dorsal and origin of anal. The snout projects a little more strongly beyond the mouth in *churchilli* and the anterior rays of the dorsal are rather shorter, not forming a definite lobe

The specimens of the present species were compared with 7 type specimens of *H argyritis*, recorded from the upper Missouri basin, and originally described from the Milk River The present species differs from that species also in the more slender body and smaller scales. In *argyritis* the snout projects beyond the mouth even more strongly than in *H churchilli*.

Specimens of *Hybognathus churchilli* studied —a. Seven specimens (including the type), ranging in length from 62 to 105 mm , from the Cheyenne River, near the mouth of Cherry Creek, taken July 15, 1928 b. Three specimens, ranging in length from 63 to 65 mm , from the White River near the town of White River, taken June 18, 1928 c One specimen, 78 mm. long, from Bad River near Midland, taken July 16, 1928. The specimens were all collected by Dr E. P. Churchill, who informs the writer that the Cheyenne and White Rivers are shallow, swift alkaline streams with little vegetation, whereas the Bad River is not alkaline, is sluggish and supports considerable vegetation. *Hybognathus nuchalis* also was taken in these rivers.

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GEOPHYSICS.—*The solution and colloidal dispersion of minerals in water.*[1] P. G. NUTTING, U. S. Geological Survey.

During ordinary weathering, parts of decomposed rocks go into solution and into suspension in water solutions that are usually either very dilute and abundant or else nearly saturated and scanty. Little is known of the details of what goes on but there are indications that the same parent rock may yield a number of different types of clays and soils under different conditions and degrees of weathering and it seemed worth while to attack the problem in the laboratory. The clay material of a decomposed granite has been converted into a bleaching clay and a commercial bleaching clay into a plastic ball clay by water treatment alone. The experiments leading to these results and some of the theory will be briefly summarized in this paper.

Since a clay suspension in water is most stable at the isoelectric point, it follows that the isoelectric condition is most favorable for particles leaving the parent solid and going into suspension. The amphoteric oxides (of Fe, Al and Si), of which most detrital rocks are chiefly composed, will therefore disperse most readily in pure water or in water carrying these same materials in solution In the absence of chemical reaction, solution ordinarily occurs most readily in pure water and is only slightly affected by materials other than alkalies in suspension or solution. Although suspensions and solutions of the same material shade into each other as molecular dimensions are approached, neither appear to have any influence on the concentration of the other aside from the very slight one indicated by kinetic theory.

A clay put in 4 to 10 times its weight of distilled water in a pyrex glass and kept at 80°C. will reach half saturation in about one or two hours, at room temperature in about 24 hours. The usual program

[1] Published by permission of the Director, U. S Geological Survey Received April 8, 1932.

was to heat on a steam bath (75–80°C.) for 20 hours, then filter through the clay itself. Room temperature saturation is usually about 2/3 the concentration reached at 80°C. The clear filtrate, showing no scattered light in a strong beam, may be concentrated to about a hundredth of its volume before precipitation begins. A hot clear filtrate may be cooled without any precipitation. But if a solution is boiled down in contact with the clay, its concentration is not increased on evaporation, indicating that the solution is saturated. Solutions of clays and rocks therefore are saturated at low concentration but these saturated solutions are capable of high supersaturation if evaporation takes place away from contact with the dissolved material.

The chief materials studied were decomposed granites from the District of Columbia, diabase from Virginia, two commercial bleaching clays, weathered dunite from Webster, N. C., two bentonites and a number of silica gels used as comparison standards The objective was to find the effect of long continued treatment with pure water,

TABLE 1 —PROPERTIES OF STABLE SILICA SOLS

	Parts per million		
Concentration	2000	6000	16000
Dialysis, 2 wks 60 cm ^{2}	58	25	15
Solubility, H_2O, 100°C	150	225	300
Salt residue	100	100	100

and incidentally to find limits of concentration, the nature of the material dissolved and in suspension, surface activation and the relation, if any, between dissolved and suspended matter.

A freshly made silica gel, stabilized and washed free from salt, goes over into a sol on standing two or three weeks. This sol gradually settles into three stable layers containing approximately 2, 6, and 16 grams per liter of silica in solution and suspension, any excess silica settling out as a floc Samples removed with a pipette gave the data (taken in 1926) given in Table 1 Weight of solids was taken after heating to about 200°C. Dialysis was through a 60 cm.^{2} collodion membrane for two weeks. The solubilities are of the ignited (800°C.) residues and showed no decrease on repetition of the test. Decided differences between the three stable sols are indicated. Impurities (salts, etc) were less than 2 parts per million. The presence of acids or of acid or neutral salts in the water appears to have but little effect on the solubility but the presence of alkalies or of strongly basic salts has a large effect. The addition of sodium chloride precipitated all but 100 parts per million of silica in each experiment.

An interesting relation was found between the amount of solids left in suspension and the salt (NaCl) concentration, namely

$$\frac{C - C_\infty}{C_0 - C_\infty} = e^{-ks}$$

in which C is the silica and s the salt concentration in grams per liter, and the constant k is 0.30. The maximum concentration of silica, C_0, is either 2, 6, or 16 grams per liter according to the sol used, while the minimum concentration C_∞ obtained with excess salt is 0.10 gram per liter for all these sols. Half the maximum concentration of silica is given by the addition of 2.50, 2.37, and 2.33 grams per liter of salt to the three sols.

Silica gel, granulated, gave a solubility at 75° of about 300 parts per million, at room temperature about 180 parts per million. Three samples were of my own preparation, one was commercial (Patrick). In concentrating the solutions (50 cc. in a platinum dish), precipitation began only at concentrations in the neighborhood of 16 grams per liter, which appears to be the upper limit of supersaturation. The stable suspension of this concentration mentioned above began to precipitate at once on boiling down.

Decomposed granite from the District of Columbia, high in iron but containing free quartz grains, was dried and put through a 150 mesh (0.10 mm.) sieve. This showed an initial saturation of 73 parts per million and a decrease to 50 parts per million in the fourth wash and 35 parts per million in the eighth. Some of the clay from the fourth wash was kept at 75°C. for two weeks when it gave 54 parts per million. Several solutions of this granite were concentrated in Pyrex vessels, then filtered through paper (S & S, 589, blue ribbon). One gave 4500 parts per million after filtering. Others boiled down in the flask with the clay to a tenth the original volume showed no increase in concentration. The solubility of this clay appears to steadily decrease. After 9 washes a small sample (15 grams in 1500 cc.) was put in a large excess of water in an attempt to reach an end point. After 3 weeks in 3 changes of water, (equivalent to more than 50 ordinary washes) the solubility reached was 32 parts per million, but 6 days were required to reach saturation. On the other hand the Virginia diabase clay showed a constant solubility of 47 parts per million from the start through 6 washes, appearing to have already reached equilibrium by natural leaching.

A yellow decomposition product derived from dunite, that had been

partly altered to serpentine, from Webster, N. C., dropped in solubility from 325 parts per million in the first wash to 50 parts per million in the fifth and thereafter decreased only slightly This same material was given an acid treatment to remove bases (chiefly iron and magnesium) leaving a white nearly pure silica which had the solubility of silica gel, 290 parts per million.

A bleaching clay from near Death Valley also high in magnesium showed an abrupt drop from an initial solubility of 250 to less than 100 parts per million, decreasing to about 90 parts per million in the fifth wash. The well known "Floridin" bleaching clay shows a more gradual decrease between about the same limits. Both these bleaching clays, on continued washing with pure water, became highly plastic like ball clays and lost most of their bleaching power. A yellow decomposed granite from the District of Columbia, the Virginia diabase and the North Carolina dunite all were converted into bleaching clays better than the average commercial grade by the water leaching alone. Doubtless it would be possible to leach them further to ball clays. In fact the excessively leached granite mentioned above appears to be approaching this stage.

All of this evidence supports a view expressed in previous papers, that bleaching clays are partly leached decomposed igneous rocks, part way on the path toward inactive clays. The partial leaching results in open bonds on actively adsorbing surfaces where complete leaching would result in the exchange of all exchangeable bases for H and OH and lead eventually in some clays to recrystallization as kaolin.

All the materials studied settled clear after the first wash but all the natural minerals worked with tend to remain indefinitely in suspension after several washes. Previous natural leaching has been such as to leave some soluble material (organic acids, salts, or organic silicates) which prevented an approach to the isoelectric point, hence the rapid clear settling in the first wash

Many of the residues from the various clay solutions were analyzed by C. S Howard and showed nearly pure SiO_2 in every one after the first few washes Silica gel and acid treated clays of course give SiO_2 alone. Even the granite and dunite solutions gave negative tests for iron and aluminum, both of which come off readily in acid. However, when water removes silica from ferric- and alumino-silicates, it does not leave iron and alumina in suspension as might be expected. Further, the open bonded surfaces which are the seat of the selective adsorbing (bleaching) power may be on any one of three oxides Fe_2O_3, Al_2O_3, or SiO_2 (or even MgO) or on combinations of these. Open

bonded pure SiO_2 surfaces, as in silica gel or acid treated clays, are excellent adsorbents for solvent vapors but only fair bleaching agents for hydrocarbon oils. The best bleach known is a compound silicate, naturally weathered.

Most residues of clay solutions show organic matter which persists through extended leaching but is removable between 150°C. and 800°C. on ignition. An organic silicate is indicated by its behavior but further work will be required to identify it The solution from a silica gel, removed with a pipette, does not show it, while the same

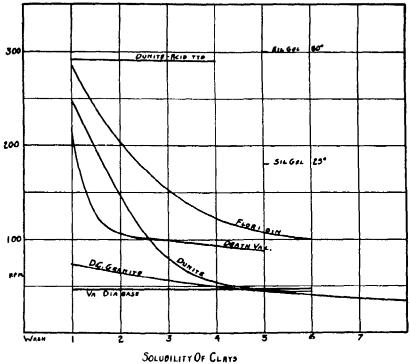

Figure 1 —Solubility of clays

solution put through filter paper does. The odor suggests furfural which is plausible since this is readily formed from cellulose and from pentosans by simple dehydration

Active silica is known to attack loosely held organic radicals and this suggests a new (third) theory for the origin of petroleum, namely, that active silica and silicates laid down and intermingled with decaying vegetation form soluble organic silicates which are later transported and decomposed, setting free hydrocarbons Experiments are under way to reproduce this cycle in the laboratory. Much indirect evidence

has already been accumulated and the theory appears simple and plausible from a chemical standpoint. Some silicified woods fuse to a viscous glassy paste below 800°C. when ignited. Silica gel is not even softened at that temperature.

Amorphous silica, even when freshly deposited from solution without heating, may have a very low solubility approaching that of quartz Oat hulls contain 7 per cent silica in a beautiful very fine grill near the surface but this silica is nearly insoluble even in hot water, although it must have been brought up from the soil in cold solution. Of two samples of silica sinter deposited by two Yellowstone geysers (supplied by Dr. E T Allen), one showed only the solubility of quartz, the other that of silica gel (180 parts per million) Both were white, very porous, and each had a refractive index below 1.45, and neither was birefringent In other experiments on the silicification of wood, the deposited silica has a low solubility as though retained by the lignin

The solubility of the silica of clays and of many other minerals is a minimum in pure water and is increased by even traces of acid or alkali in the water. A yellow clay, rich in iron, that had reached a solubility of 35 parts per million was treated with water containing 1.500 HCl. The solution showed 102 parts per million of silica which had apparently been released by removal of some of the bases (previously associated with silica) over the grain surfaces. Silica thus released has a solubility approaching that of silica gel. Slight alkalinity of solvent water likewise gives enhanced solubility of silica, even of that firmly associated with bases.

As a test of reversibility, clay having a fixed solubility of 35 parts per million was put in a saturated solution (300 parts per million) of silica and kept at 80°C. for 24 hours The clay actually removed more than half the silica in solution, presumably as an adsorbed layer on the clay particles.

Summary.—Saturated solutions of many ordinary clays and decomposed rocks in pure water after repeated washing range in concentration from 30 to 100 parts per million.

Saturation at 80°C. is roughly a half greater than at 25°C. in concentration.

Saturation is approached in 10 hours at 80°C. and in 400 hours at 25°C. Bound and slowly circulating water in clays is commonly nearly saturated.

True rock solutions free from particles in suspension may be concentrated to several thousand parts per million without precipitation.

Mechanical disintegration into suspensions is favored near the

isoelectric point, a condition approached only after several washings of a raw clay or decomposed rock in pure water.

Organic matter is commonly associated with silica as soluble silicates which may be transported and decomposed elsewhere into silica and hydrocarbons.

Many decomposed igneous rocks may be converted into bleaching clays by the action of water alone but the high quality of the best bleaching clays depends to some extent on the composition of the original rock.

Many bleaching clays may be converted into plastic ball clays by the action of water alone.

GEOLOGY.—*Geothermal gradient at Grass Valley, California.*[1] W. D. JOHNSTON, JR., U. S. Geological Survey. (Communicated by W. H. BRADLEY.)

During the field seasons 1930 and 1931 the writer was engaged in studying the underground geology of the gold quartz mines at Grass Valley, California,[2] where the mine workings have attained a maximum vertical depth of 3,700 feet beneath the surface.

In the course of underground mapping at the Empire-Star Mine, temperature measurements were taken on twenty-one different levels. These temperature observations were made in air or in standing water, usually on the drift face, and always outside the path of air circulation. From three to six observations were made on each level, and the temperature given in the following table is an average for the level. The value for the North Star 9,000 level is a rock temperature, obtained by averaging the readings of three maximum thermometers, which had remained for twenty-four hours in a bore hole 4 feet deep near an advancing face.

The temperature data were adjusted by a method adopted several years ago by C. E. Van Orstrand which consists in adjusting a series of straight lines from the shallowest depth at which a temperature test is made to a number of gradually increasing depths as shown in the last column of Table 1.

The equation to be adjusted each time is

$$y = a + bx$$

[1] Published by permission of the Director, U. S. Geol. Survey. Received March 25, 1932.

[2] Lindgren, Waldemar. *The gold quartz veins of Nevada City and Grass Valley districts, California.* U. S. Geol. Survey, Annual Report 17: Part 2, 1–263. 1896.

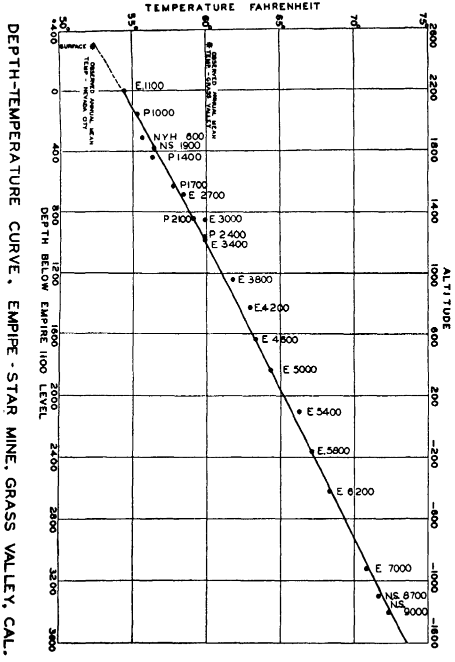

Figure 1 —Depth-temperature curve at the Empire-Star Mine, Grass Valley, California.

TABLE 1 —TEMPERATURE GRADIENT AT THE EMPIRE-STAR MINE, GRASS VALLEY, NEVADA COUNTY, CALIFORNIA[a]

Location of temp observation		Depth[b]		Observed temperatures		0-980 Ft		0 3400 Ft	
Mine	Level	Meters	Feet	Cent	Fahr	Comp temp	Obs minus comp	Comp temp	Obs minus comp
Empire	1100	0 0	0	12 4	54 4	54 2	+0 2	54 6	−0 2
Pennsylvania	1000	45 7	150	12 9	55 3	55 1	+0 2	55 4	−0 1
New York Hill	600	94 5	310	13 1	55 6	56 0	−0 4	56 3	−0 7
North Star	1900	114 3	375	13 6	56 4	56 3	+0 1	56 6	−0 2
Pennsylvania	1400	128 0	420	13 5	56 3	56 7	−0 4	56 8	−0 5
Pennsylvania	1700	192 0	630	14 3	57 7	57 9	−0 2	57 9	−0 2
Empire	2700	207 3	680	14 7	58 5	58 2	+0 3	58 2	+0 3
Pennsylvania	2100	256 0	840	15 1	59 1	59 1	0 0	59 1	0 0
Empire	3000	257 5	845	15 3	59 5	59 2	+0 3	59 1	+0 4
Pennsylvania	2400	292 6	960	15 5	59 9	59 9	0 0	59 7	+0 2
Empire	3400	298 7	980	15 5	59 9	60 0	−0 1	59 8	+0 1
Empire	3800	377 9	1240	16 6	61 8	61 5	+0 3	61 2	+0 6
Empire	4200	432 8	1420	17 2	62 9	62 6	+0 3	62 1	+0 8
Empire	4600	496 8	1630	17 4	63 3	63 8	−0 5	63 2	+0 1
Empire	5000	559 3	1835	17 9	64 3	65 1	−0 8	64 3	0 0
Empire	5400	640 1	2100	19 0	66 2	66 6	−0 4	65 7	+0 5
Empire	5800	719 3	2360	19 5	67 1	68 2	−1 1	67 1	0 0
Empire	6200	795 5	2610	20 2	68 3	69 7	−1 4	68 4	−0 1
Empire	7000	951 0	3120	21 6	70 8	72 7	−1 9	71 1	- 0 3
North Star	8700	1005 8	3300	22 0	71 6	73 7	−2 1	72 0	−0 4
North Star	9000	1036 3	3400	22 4	72 3	74 3	−2 0	72 5	−0 2

Constants[c]	0-980 ft	0 2100 ft	0-3120 ft	0-3400 ft
a =	54 17	54 32	54 55	54 63
b =	0 00593	0 00569	0 00537	0 00527
$1/b$ =	168 6	175 8	186 1	189 8
r =	±0 18	±0 21	±0 25	±0 26
r_a =	±0 11	±0 10	±0 10	±0 09
r_b =	±0 00017	±0 00009	±0 00007	±0 00005

[a] Observations made in 1930 31 Most of the observations were made in air or standing water outside of the path of air circulation

[b] Depth below Empire 1100 level, altitude 2200 ft, which is taken as the temperature datum This is about 300 ft below the surface of the ground

[c] Constants have been determined by the method of least squares from the equation $y = a + bx$

in which

y = temperature at depth x

a = computed annual mean temperature just beneath the surface of the earth

b = gradient in degrees Fahrenheit per foot

$1/b$ = reciprocal gradient in feet per degree Fahrenheit

r = probable error of observation y, weight unity.

r_a, r_b = probable error of a and b

All of the computations in this paper were carried out by Mr H.

Cecil Spicer, Assistant in the Physical Laboratory of the Geological Survey.

The depth-temperature curve (see Fig. 1) is slightly concave toward the depth axis. This is clearly shown in the following values of the reciprocal gradients taken from Table 1

From 300 to 1280 feet, 1°F. for every 168.6 feet.
From 300 to 2400 feet, 1°F. for every 175.8 feet.
From 300 to 3420 feet, 1°F. for every 186.1 feet.
From 300 to 3700 feet, 1°F for every 189 8 feet.

As the rock temperature on the 9000 level of the North Star mine is only 72.3°F, underground temperature offers no hindrance to mining operations

TABLE 2—TEMPERATURE OF DEEP MINES

	Observed T at 100 feet	Greatest depth	Observed T at greatest depth	100 to 1000 ft				100 ft to greatest depth			
	Fahr	Feet	Fahr	a	b	1/b	r	a	b	1/b	r
Grass Valley, Calif	54 4[a]	3700	72 3	54 17	0 00593	168 6	0 18	54 63	0 00569	189 8	0 26
Mother Lode, Calif [b]		4200	86 0					64 39	0 00520	192 3	1 73
Calumet, Mich [c]	44 6	5367	89 7	42 47	0 01009	99 1	0 65	43 44	0 00852	117 4	1 31
" " [d]		5679	95 3							108 5	
Minas Geraes, Brazil[c]		6140	115 7						0 00801	124 8	
Johannesburg, S Africa[c]		7032	97 0						0 00495	202 1	

[a] 300± ft

[b] Knopf, Adolph *Mother Lode system of Calif* U S Geol Survey, Prof Paper 157 22-23 1929 Gradient recalculated from Knopf's data by H Cecil Spicer

[c] Van Orstrand, C E *On the nature of isogeothermal surfaces* Am Jour Science, 15 509-11 1928

[d] Ingersoll, L A *Geothermal gradient determinations in the Lake Superior copper mines* (abstr) Physical Review, 39 No 5, 869-70 1932

In Figure 1 the observed surface mean annual temperature at Grass Valley and Nevada City are shown. The mean annual temperature for Nevada City,[3] six miles north of the mine, obtained over a period of 39 years, is 52.6°, agreeing with the calculated subsurface temperature within 1°. The mean annual temperature near the mine at Grass Valley,[3] however, taken over a period of only 22 years is 60.3° or 7° higher than the calculated subsurface temperature.

The thermal gradient at Grass Valley, as shown in Table 2, is in

[3] U S Weather Bureau Climatological Data, 17: No 13, 88-99. 1930

close agreement with the thermal gradient on the Mother Lode.[4] It slightly exceeds the gradient in the Rand, S. Africa, and is much less than the gradient in the Michigan copper mines and in the St. John del Rey mine, Brazil.

[4] Knopf, Adolph *Mother lode system of California* U S Geol Survey Prof Paper 157: 22–23 1929 Knopf gives a gradient of 1°F for 150 feet His data have been recalculated by the method of least squares by H C Spicer, who obtained a reciprocal gradient of 192 3 feet per degree Fahrenheit from observations between the depths of 1575 and 4200 feet Knopf's values for the Central Eureka and the Kennedy mines apparently are based on an assumed value of the mean annual temperature *y* of the air

ZOOLOGY.—*A new trematode,* Acanthatrium eptesici, *from the brown bat.*[1] JOSEPH E. ALICATA, Bureau of Animal Industry. (Communicated by BENJAMIN SCHWARTZ.)

Three flukes representing a new species of trematode belonging to the family Lecithodendridae Odhner, 1910, and to the genus *Acanthatrium* Faust, 1919, were collected by the writer in November, 1931, from the intestine of the brown bat, *Eptesicus fuscus*, captured in Washington, D. C. The new species is described in this paper.

Acanthatrium eptesici, new species

Figs 1 and 2

Specific diagnosis—*Acanthatrium* Body rounded, flattened dorsoventrally, from 702μ to 1 2 mm long by 468 to 764μ wide in middle of body Cuticular spines absent Oral sucker subterminal, 98 to 114μ long by 98 to 114μ wide, acetabulum 72 to 98μ long by 80 to 98μ wide Prepharynx absent, pharynx 38 to 45μ long by 49 to 53μ wide, esophagus 34 to 76μ long Intestinal ceca short, simple, extending to anterior margins of testes Excretory bladder V-shaped Testes ovoid to pyriform, located on same zone as acetabulum, and transverse in position, right testis 121 to 281μ long by 129 to 205μ wide, left testis 121 to 258μ long by 91 to 197μ wide Seminal vesicle long and coiled, prostate cells numerous, forming a mass 121 to 327μ long by 186 to 358μ wide The entire mass is enclosed in a delicate sac-like membrane Genital pore somewhat anterior to acetabulum and anterior to zone of testes. Genital atrium slightly anterior to genital pore, and lined with one group of long, narrow spines Ovary ovoid, regular or lobed, the largest axis transverse, oblique or longitudinal in position Vitellaria composed of large follicles which may extend from about level of pharynx to anterior margins of testes Uterus long and arranged for the most part transversely, occupying posterior half of body length and terminating in a moderately developed metraterm Eggs oval, 20 to 30μ long by 15μ wide, with yellowish brown, thin shell

Host.—*Eptesicus fuscus*

Location—Small intestine

Distribution—United States (Washington, D C)

Type specimen—U S N M Helm Coll No 30135, paratypes No 30136

Acanthatrium eptesici differs from the other two species of the genus, namely *A. sphaerula* (Looss, 1896) Faust, 1919, and *A. nycteridis* Faust, 1919,

[1] Received March 16, 1932.

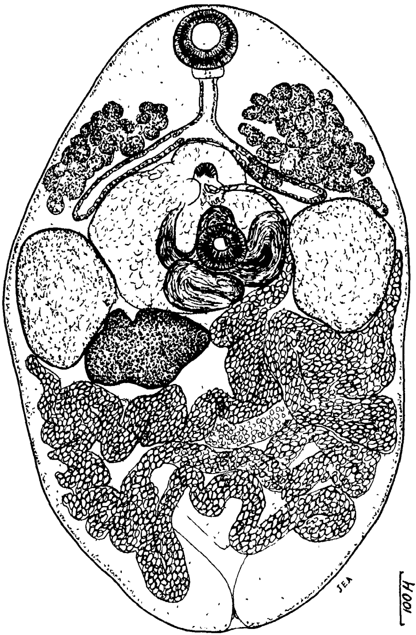

Fig 1 —*Acanthatrium eptesici*, Alicata Ventral view.

as follows: The genital atrium in *A. sphaerula* has spines distributed over its entire wall and the genital pore opens at the right side of the prostate gland mass, whereas in *A eptesici* the spines are limited to a semicircular area of

the anterior wall of the genital sinus, and the genital pore opens in the median line at the anterior end of the prostate gland mass. The ovary in *A. sphaerula* is triangular and deeply lobed, and extends anterior to the right testis and prostate gland mass. In *A. eptesici* the ovary is more or less ovoid in outline, entire or slightly lobed, extending along the posterior portion of right testis and posterior to the prostate gland mass. The acetabulum in *A. sphaerula* is posterior to the zone of the testes and prostate gland mass, while in *A. eptesici* the acetabulum is on the same zone with the testes and prostate gland mass.

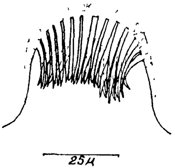

Fig. 2.—*Acanthatrium eptesici*, showing arrangement of spines in the genital atrium. Ventral view.

A. nycteridis differs from *A. eptesici* in having the spines of the genital atrium arranged in three separate groups, as illustrated by Faust (1919). Two specimens collected by the writer from the brown bat and identified as *A. nycteridis* show this characteristic arrangement of spines (Fig. 3). In

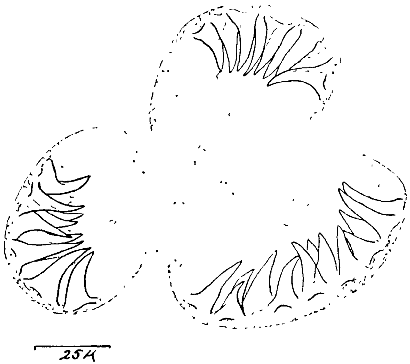

Fig. 3.—*Acanthatrium nycteridis*, showing arrangement of spines in the genital atrium. Ventral view.

this species the spines vary from 15 to 22μ in length by 7 to 11μ wide at the base. *A eptesici* has long narrow spines, 11 to 22μ long and about 2 to 4μ wide at the base and arranged in a single group (Fig 2) The acetabulum in *A nycteridis* is post-testicular, while in *A. eptesici* it is located in the testicular zone.

Bhalerao (1926) collected some trematodes from a bat which he believed to be morphologically identical with *A nycteridis*. However, since the uterine coils were arranged transversely and measurements of the body and suckers were somewhat larger than those reported by Faust (1919), he proposed a new variety, *A nycteridis plicati*. Since measurements are the main differences and the arrangement of spines on the genital atrium are presumably like *A nycteridis*, differentiation of this variety from *A. eptesici* is the same as for *A nycteridis*

THE GENUS *ACANTHATRIUM*

Faust (1919), characterized the genus *Acanthatrium* as having the testes pre-acetabular in the same zone as the genital pore, and the vitellaria anterior to the intestinal ceca These characters may hold true for *A sphaerula* and *A nycteridis*, but do not hold true in all cases for *A eptesici*, which has the testes in the acetabular zone, moreover, the vitellaria of the latter species may or may not extend posterior to the intestinal ceca It is, therefore, essential that the diagnostic features of the genus *Acanthatrium* be modified as follows. *Lecithodendriinae*, small flukes, spherical to pyriform in shape, with a genital atrium lined with spines, prostate cells numerous; testes in acetabular or pre-acetabular zones, vitellaria anterior or posterior to intestinal ceca; excretory system, according to Faust (1919), with four groups of flame cells for each half of the body, each group containing three flame cells Parasites of the intestine of bats Type species *A nycteridis* Faust, 1919

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ZOOLOGY.—*A new squirrel from Honduras* [1] E. A. GOLDMAN, Biological Survey

The veteran collector of specimens and student of the natural history of Costa Rica, Mr. C. F Underwood, has recently transferred his activities to the interior of Honduras. Among the mammals obtained

[1] Received April 12, 1932.

is a squirrel which appears to have remained undescribed until the present time.

Sciurus boothiae underwoodi subsp nov

Underwood's Squirrel

Type —From Monte Redondo, about 30 miles northwest of Tegucigalpa, Honduras (altitude 5,100 feet) No 250219, ♂ adult, U S National Museum (Biological Survey collection), collected by C F Underwood, December 8, 1931. Original number 644

Distribution.—Known only from the type locality in the mountains of central Honduras

General characters —Approaching *Sciurus boothiae boothiae* of northern Honduras, but upper parts much paler, the general color grayer, less blackish, and lacking the rufescent suffusion present in *boothiae* Contrasting strongly with *S b annalium* from "Honduras" in white under parts, sharply defined laterally, instead of gray, passing gradually into color of sides Somewhat similar to *S variegatoides variegatoides* of Salvador above, but under parts white instead of tawny General coloration suggesting that of *S goldmani* of Chiapas, Mexico, but markedly distinctive in detail, as follows Post-auricular spots buffy instead of white, feet dark ochraceous buffy or black instead of gray, dark ochraceous buff lateral line normally present (absent in *goldmani*), tail more extensively white

Color —Type Upper parts in general light buff, moderately overlaid with black, outer sides of limbs and feet ochraceous buff mixed with black, under parts, including inner sides of forearms and thighs nearly pure white, a broad ochraceous buff lateral line sharply separating abdominal area from general tone of upper parts, ears narrowly edged with black, the tufts scanty and indistinctly tawny, post-auricular spots extending up over median posterior basal part of ears, ochraceous buff, feet edged along inner sides with ochraceous buff, tail above conspicuously overlaid with silvery white, the long white tips of hairs partially concealing a subterminal black zone, below annulated, the hairs ochraceous buff at base, interrupted by a narrow black band, followed by another ochraceous buff band and a subterminal black zone, the white tips forming a distinct margin In one specimen the feet are black and there is no ochraceous buff lateral line separating white of abdomen from general color of sides

Skull —About like those of *S b boothiae* and *S v variegatoides*, but broader between orbits

Measurements —Type Head and body, 241 mm, tail vertebrae, 272, hind foot, 60 Average of four adult topotypes 240 (225–250), 285 (275–300); 62 (60–65) *Skull* (type) Greatest length, 59 6, condylobasal length, 55 7; zygomatic breadth, 34 2, interorbital breadth, 21 3, length of nasals, 19 4; maxillary toothrow, 11 7

Remarks —Sciurus boothiae underwoodi is a well-marked form, but it approaches typical *boothiae* so closely in the more essential characters that assignment to subspecific status seems fully warranted Points of agreement of *boothiae* with squirrels currently recognized as *S variegatoides*, *S managuensis*, *S goldmani*, *S. adolphei*, and *S yucatanensis* strongly suggest that all are representatives of a single very variable and widely ranging species. Additional specimens are needed, however, from many regions to fill gaps in known ranges and establish more exact relationships

Specimens examined —Six, from the type locality

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

246TH MEETING

The 246th meeting of the Academy was held in the Assembly Hall of the Cosmos Club on Thursday, February 18, 1932 About 100 persons were present President ADAMS called the meeting to order at 8·20 and introduced as speaker of the evening, Doctor N A COBB of the Bureau of Plant Industry, Retiring President of the Academy, who delivered an address on *Science as illustrated in the personnel and achievements of the Academy and its eighteen affiliated societies*

The speaker emphasized the responsibility of the scientists of Washington to develop an interest in the broad problems in which science touches the general welfare as well as in the technical researches of their separate fields. The address will be published in this JOURNAL

247TH MEETING

The 247th meeting of the Academy was held in the Assembly Hall of the Cosmos Club on Thursday, March 17, 1932 About 75 persons were present President ADAMS called the meeting to order at 8 20 and introduced Doctor W H LONGLEY, Professor of Zoology at Goucher College, and Executive Officer, Tortugas Laboratory, Carnegie Institution, who delivered an illustrated address on, *The law of organic evolution and its place among the laws of kinetic systems*

The author's abstract follows —It is possible to determine very accurately, when known species of animals and plants received their accepted scientific names The date when each was first collected for scientific study may not be fixed so precisely, though patient inquiry gives a fair approximation to fact But dates of naming depend on time of finding; and time of finding similarly depends upon where species are Moreover, the geographical distribution of species is an effect of the very play of forces by which they were originally made Clearly, therefore, there is a possibility of getting new light upon evolution through analysis of the statistical data of taxonomy and distribution.

Upon inquiry it appears that, on the average, species of the smallest genera in natural groups which are collected with discrimination of material in the field get their names sooner than others, and that in other generic sizes the species enjoy no advantage one over another in the respect mentioned In respect to finding, species of larger genera tend to come to light earlier, those of smaller genera later, though this way of putting the matter does not tell quite the whole story When the detailed results of the two analyses are compared and further inquiry is made concerning the relation between time of finding and area occupied, it is ascertainable that the species of large genera occupy large, and those of small genera small average ranges

This is a fact of utmost importance. It seems impossible to explain it except by assuming that the many widespread (or able) species in the large genera are descendants of able ancestral species which have had much success in increasing the number of species of their general sort in the world, and that the few and weak species of small genera are similarly the descendants of weak ancestors which have had correspondingly small success in the production of new kinds. But to say that this is the explanation of the correlation between size of genus and average specific range within it is to affirm that evolution is a

fact, and that its process is Darwinian in principle. Variation, inheritance and natural selection—with isolation, as may be shown also—unite in bringing it to pass. The data of taxonomy and distribution establish the fact of evolution and identify the factors concerned in it

More still may be learned from consideration of the numerical relations of genera and species Evolution is not only a fact and Darwinian in principle but occurs according to law Still more, its law may be written in as definite mathematical form as the laws of the "exact" sciences, and is one of a natural group, of which the gas laws are most familiarly known

Why this should be so may be stated briefly. The laws of gases express the result of random action upon one another of their active units, the molecules. It is as unnecessary and unprofitable, however, to limit the application of kinetic theory to systems composed of such units as it would be to apply our knowledge of falling bodies exclusively to those falling from rest Within the field of an amplified kinetic theory fall possible systems whose units (always active and acting upon others at random) may be incapable of reproduction and variation, or capable of either alone or of the two together

All four suggested sorts of kinetic systems exist Normal gases are examples of the first Their laws are the gas laws so-called Glowing gases compose the second group Their units are atoms, capable of variation in state, but incapable of reproduction The exercise of their power of variability is limited by the pressure in the system The master law of such systems is the law of distribution of energy in the line spectrum If it had been the first of gas-laws to be fully worked out, the elementary laws of gases might have been derived from it by inspection

Simple populations (populations composed of a single sort of organism) are the third kind of system contemplated Their units, the individual organisms, have by definition no power of variation, but do have the power of reproduction, limited in its exercise by the "pressure" prevailing in the system The master law of such systems is the law of population growth expressed graphically by the logistic curve There are also secondary laws of simple populations, corollaries of the law of growth, which are structurally the same as the laws of gases [1]

Compound or species populations, second-order populations, such as all the individuals of all the species of each great natural group of organisms compose, are the most complex of the systems here considered Their units (species) reproduce and vary at the same time that they react with one another at haphazard The master law of these systems is a law of differentiation, or of evolution, the law which the data of taxonomy and distribution affirm to exist Their lesser laws include a law of growth according to the logistic curve and laws structurally like, or homologous with, the gas laws

It is not suggested that in these several systems the action of unit upon unit is precisely the same in kind Let the action be, for example, after an order capable of schematic representation as the result of mechanical impact between ideally elastic spheres of molecular proportions and pressure may be measured in millimetres of mercury Let it be more subtle, as it is in the organic systems, and it may be measured in terms of failure to maintain an ideal rate of increase in the absence of checks

The one method of measurement is as valid as the other, and a kinetic theory of simple and second-order populations as completely justified as a kinetic theory of gases, normal or glowing The two, in fact, are so closely akin that by omitting the specific and non-essential one statement may be

[1] Longley, W. H Science, 75. 248–250, Feb 26, 1932

made to cover both and the portion of biology which deals with species in their genera and ranges can be exhibited as an integral part of physics.

CHARLES THOM, *Recording Secretary.*

PHILOSOPHICAL SOCIETY

1019TH MEETING

The 1019th meeting was held in the Cosmos Club Auditorium, Saturday evening, March 14, 1931, President CURTIS presiding

Program W F WALLIS. *The geographical distribution of magnetic disturbances* (illustrated) —The reduction and discussion, in the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, of the magnetic records obtained by the two MacMillan Arctic expeditions of 1921–1922 and 1923–1924 afforded an opportunity for comparing the effects of magnetic disturbances in polar regions with other points on the earth's surface In addition to MacMillan's two Arctic stations at Bowdoin Harbor on the southwest coast of Baffin Island and Refuge Harbor on the northwest coast of Greenland, the records of the following stations were used in the discussion: Sodankyla, Sitka, Cheltenham, Tucson, Vieques, Honolulu, Antipolo, Huancayo, Vassouras, and Watheroo The two magnetic storms of March 14, 1922, and January 29, 1924, were selected, and comparisons were made by computing for each hour of each storm the excess energy of the magnetic field per cubic centimer (ΔE) due to the disturbance, as represented by the equation

$$\Delta E = (X_0\Delta X + Y_0\Delta Y + Z_0\Delta Z)/(4\pi) + [(\Delta X)^2 + (\Delta Y)^2 + (\Delta Z)^2]/(8\pi)$$

As a check use was made also of the expression

$$\Delta R = [(\Delta X)^2 + (\Delta Y)^2 + (\Delta Z)^2]^{1/2}$$

which represents the change in space of the total-intensity vector The numerical mean values of ΔE and ΔR for the durations of the storm and the auroral-frequency numbers of the stations as taken from Fritz's curves, when plotted in relation to magnetic latitude, indicate a close relation between the auroral frequency and the distribution of magnetic disturbances On computing algebraic, instead of numerical means of the hourly values of ΔE, it is found that the average excess energy produced by these storms is positive for the stations within the auroral zone but negative for all the other stations Evidences are presented to show that different types of magnetic disturbance are propagated around the earth with different velocities Possible causes of magnetic disturbances are briefly considered (*Author's abstract*)

Discussed by Messrs GISH and HUMPHREYS

H. C DICKINSON *Scientific automobilia* (illustrated) —Among the questions often asked by scientists and those who are interested in motor vehicle design and operation from the scientific side are some which merit particular attention

Some of the scientific as well as the practical aspects of the following subjects were discussed.

The engine and complete power-plant in relation to performance and efficiency of the vehicle, including the process of "free wheeling "

The steering mechanism, its mechanics and geometry and its relationship to safety of operation

Brakes, of various types, their capacity, limitations and safe use as related to roads and road-surfaces.

Motor fuels, in relation to starting, satisfactory operation, vapor lock, fuel knock, fuel dopes and premium fuels and fuel economy.

Lubrication, types of lubricating oils and their relationship to safe lubrication and proper operation.

Anti-freeze compounds, of three general classes, and their relative merits and demerits.

Spark plugs.

Fuel pumps

Headlighting and some of the obscure points involved in the method of highway lighting. (*Author's abstract*)

Discussed by Messrs ADAMS, GISH, HAWKESWORTH, and WHITE

1020TH MEETING

The 1020th meeting was held in the Cosmos Club Auditorium, Saturday evening, March 28, 1931, President CURTIS, presiding

Program: J W GREEN and L H ADAMS. *The effect of pressure on the magnetic inversion point in iron and other materials* (illustrated) —This coöperative investigation by L H ADAMS and J W GREEN, of the Geophysical Laboratory and Department of Terrestrial Magnetism, respectively, both of the Carnegie Institution of Washington, was undertaken principally because of its bearing on the earth's magnetic field and its relation to the problem of the central iron-cores. The object was to determine whether or not the temperature at which iron and other ferromagnetic substances pass from the magnetic to the non-magnetic state is affected by an increase of pressure.

The specimens of the materials under investigation were made up as the core of a miniature transformer or induction-unit, and placed in an electrically heated pressure-bomb A six-volt alternating-current was supplied to the primary of the transformer and the output from the secondary was amplified, rectified, and carried to a direct-reading galvanometer

The temperature of the inversion-point, indicated by the galvanometer reading dropping to zero, was measured by means of platinum-platinrhodium thermocouples

Five ferromagnetic metals were used in the investigations, namely, iron, nickel, nickel-steel, magnetite, and meteoric iron The pressure medium was carbon-dioxide and determinations were made at pressures up to 2,000 atmospheres for iron and magnetite, 2,200 atmospheres for nickel, 2,600 atmospheres for nickel-steel, and, in the case of meteoric iron, 3,600 atmospheres The results indicate that pressure has practically no effect on the inversion-point, although the possibility of a slight decrease is not excluded as there was a slight tendency toward depression, especially in the case of nickel-steel and meteoric iron

On the whole, it seems a fair inference that the pressure-coefficient of the magnetic inversion-point remains zero or negative even at the high pressures in the earth's interior and that consequently the permeability of the nickel-iron core of the earth is not significantly higher than that of ordinary rocks (*Authors' abstract*)

The paper was presented by J W GREEN and was discussed by Messrs ADAMS, BRICKWEDDE, GIBSON, GISH, HECK, HUMPHREYS, and TUCKERMAN

R F. MEHL *Radiography with gamma rays* (illustrated) —The studies carried out at the Naval Research Laboratory during the last two years upon the use of gamma rays from radium or radon for the inspection of metallic objects (castings, welds, etc) for defects were described The physical characteristics of gamma rays which distinguish the radiographic results obtained from those of X-rays were pointed out and briefly discussed An experimentally determined exposure curve relating thickness to exposure time (milligram-hours) serves to determine the length of exposure for any given

object The application of the method to two large castings in Naval vessels was described and illustrated. The definition and sensitivity obtained is entirely satisfactory, even up to 7" of steel Radiographs have been prepared of thicknesses over 10", but the requirement of radium or of exposure time becomes very great Research now under way indicates the successful development of faster films, which will mean that the exposure times now necessary will be greatly diminished or (which amounts to the same thing) lesser quantities of radium will be required. (*Author's abstract*)

Discussed by Messrs BRICKWEDDE, HAWKESWORTH, and TUCKERMAN

Informal communication L B TUCKERMAN *Inelastic impact of three perfectly elastic and perfectly smooth spheres*

Discussed by GIBSON

1021ST MEETING

The 1021st meeting was held in the Cosmos Club Auditorium, Saturday evening, April 11, 1931, President CURTIS presiding

Program A B LEWIS, E L HALL, and F L COLWELL· *Some properties of foreign and domestic micas* (illustrated) —A number of samples of mica, fairly representative of the major sources of the world's supply of mica, have been tested for their dielectric constant, power factor, dielectric strength, and ability to withstand elevated temperatures Average values are given for the dielectric constant and power factor at radio frequencies, and for the deviations from these average values which must be expected in commercial lots of mica It is shown that stains and inclusions seriously affect the power factor of a sample, but have much less effect on the dielectric strength Most of the samples were unaffected by exposure to temperatures up to 600°C, but above that temperature only the phlogopites can be said to have successfully withstood the elevated temperatures On the basis of these data it was not possible to distinguish between micas of like commercial grades obtained from different geographical localities (*Authors' abstract*)

The paper was presented by A B LEWIS and discussed by Messrs. SILSBEE, BROMBACHER, PIGGOTT, HUMPHREYS and CURTIS

EMBERT A LELACHEUR. *Tidal phenomena in Long Island Sound* (illustrated). (Published in this JOURNAL 21: 239)

Discussed by Messrs HUMPHREYS, MARMER, and CURTIS

1022ND MEETING

The 1022nd meeting was held in the Cosmos Club Auditorium, Saturday evening, April 25, 1931, President CURTIS presiding

Program. W J PETERS and J W GREEN. *A photographic method of changing the ratio of ordinate-scale to abscissa-scale* (illustrated) —This method is proposed for the purpose of reproducing magnetograms or other continuous photographic records made at different observatories on the same scales as regards both time and value of magnetic or other recorded element with all the minutiae of detail Two photographic exposures are made, one of the photographic record, the second of the resulting negative In both exposures the sensitized paper is inclined at predetermined angles which depend upon the magnifications required of the abscissae and ordinates, respectively, and upon the condition that the respective scales be uniform throughout the final positive Theoretically there is no limit to the choice of ratio desired between the scale of ordinate and the scale of abscissa Practically the limit is fixed by the depth of focus available, and the smallest stop usable, or by the number of repetitions of the operation of two exposures. Experiments were made in which the final ordinates were made about three times as long as the original

with respect to the abscissae in the one operation of two exposures (*Authors' abstract*)

The paper was presented by W J PETERS and discussed by Messrs BRIGGS and TUCKERMAN

CHARLES BITTINGER: *Color* (illustrated) —The technique of painting changeable pictures which are perfectly normal in day-light or ordinary artificial light, is done by using pigment mixtures which have a subjective similarity but an objective difference

The reason our organs of sight do not detect this objective difference is due to the fact that the eye is not an analytical receptor, that is, the eye does not examine the component parts of the sensation but accepts it as a unit

When pictures containing these pigments are illuminated by light containing a few adjacent wave-lengths, a different brightness relation takes place; when the pictures are illuminated by dichroic or trichroic light, a hue difference as well as a relative brightness difference takes place In this way a new picture can be made to take the place of the one seen in white light

A fleeting after-image was demonstrated by means of a Bidwell rotating disk A red light was made to turn green when seen through the open segment A change in frequency, brightness ratios, or observer may weaken the effect or cause the appearance of other phases of the complete after-image None of the attempts at explaining the entire phenomenon is generally accepted (*Author's abstract*)

Discussed by Messrs LAMBERT, CRITTENDEN, WRIGHT and MEGGERS

1023RD MEETING

The 1023rd meeting was held in the Cosmos Club Auditorium, Saturday evening, May 9, 1931, President CURTIS presiding

Program H L DRYDEN *Motion pictures of the flow of air and of the travel of sound waves* (Japanese highspeed movies) The films which were exhibited were taken in the laboratories of the Aeronautical Research Institute of Tokyo Imperial University, Tokyo, Japan, by Professor T Suhara and his assistants under the general supervision of Baron C Shiba, the director of the institute The films were presented to Dr George K Burgess, the director of the Bureau of Standards, by Baron Shiba These pictures, commonly known as the Baron Shiba pictures, have attracted world-wide attention, some of them having been made at the amazing speed of 40,000 pictures per second

The motion of air may be made visible in two ways The first is by the use of floating bodies, such as balloons, particles of dust, or smoke-clouds The motion of these objects represents the motion of the air only insofar as the weight, size, and temperature of the particles do not produce differences We may also in a sense see the motion of air in another way, namely, by means of the changes in density produced by the motion The changes in density deflect rays of light from a straight line Everyone has in this manner "seen" the air rising from a hot body such as the radiator of an automobile One may also stand in the wind with a long thin plate such as a saw-blade and, sighting along the edge toward some bright object, see the "waterfall" over the edge In the pictures shown there were examples of both methods

Three reels dealt with the flow of air made visible by smoke The smoke itself is rather interesting. Studies in this country have been made either by the use of titanium tetrachloride, the smoke of the smoke-screen or smoke-bomb and incidentally highly corrosive, or by the use of tobacco-smoke. Professor Suhara used an incense-smoke, the smoke from sênko, a substance commonly burned in Japan when visiting tombs

The air-flow was produced by a suction fan at one end of a long box with glass side walls, the box being about 7 feet long, 2 feet deep, and 1-1/2 inches wide, i e between the glass walls The glass walls were vertical and the models were placed horizontally between them Upstream from the model was placed a vertical pipe with a number of small holes from which the smoke issued. The speed of the air was about 7 miles per hour and the pictures were taken with a commercial high-speed camera at the rate of 120 per second. The smoke-particles therefore moved about 1 inch between exposures and the separate particles were not seen, the smoke-streams appearing as white lines. The field of view covered by the camera was roughly 1 foot square The flow about a flat plate, a triangular prism, a circular cylinder at rest and rotating, a semi-circular barrier and an elliptic cylinder were illustrated by the first film The second film showed the flow around various airfoil sections used for airplane wings, and the third film showed the flow through various types of orifices, nozzles, and valves

The fourth film showed some pictures of the travel of sound-waves, taken at a rate of 40,000 pictures per second, the sound-waves being made visible by their effect in deflecting rays of light from a straight line.

The camera is very ingenious A single strip of film about 12 feet long is secured along the inner surface of a drum about 4 feet in diameter, which is rotated at about 3750 r p m The heart of the mechanism is a revolving mirror in the shape of a frustrum of a regular polygonal pyramid of 180 sides which is rotated at approximately 14,000 r p m The image is formed on the film by a fixed lens Light after passing through the lens is reflected from each of the 180 mirrors in turn to the film, the relative speeds of the film-drum and rotating mirror being such that the image is stationary with respect to the film The pictures taken by the camera are about 1/7-inch square and about 1,000 can be taken on a strip of film At a rate of 40,000 per second, pictures can be taken continuously for about 1/40 second The small pictures are enlarged to standard size

The film showed the travel of sound-waves set up by an electric spark in enclosures of various shapes, circular, triangular, and elliptical (*Author's abstract*)

Discussed by Messrs CURTIS, HUMPHREYS, and TUCKERMAN

Informal communication W J HUMPHREYS: *The vibration of stretched wires exposed to strong air-currents*

Discussed by Messrs HAWKESWORTH, TUCKERMAN, and DRYDEN

G R. WAIT, *Recording Secretary*

1024TH MEETING

The 1024th meeting was held in the Cosmos Club Auditorium, Saturday evening, May 23 1931, President CURTIS presiding

Program: C MOON: *Problems in the measurement of the length of a single layer solenoid with an accuracy of one part in a million* (illustrated)

Discussed by Messrs HEYL, TUCKERMAN, DRYDEN, JUDSON, KSANDA, L. H ADAMS, and GISH

P R HEYL. *The prospective of modern physics* —The most striking feature of modern physics both from its strangeness and its ubiquity, is the radical change in the nature of the concepts dealt with, a change away from materialism and toward the insubstantial Matter has become a form of energy, atoms are vibration in something the nature of which is not yet clear. Nothing remains but shadows of former realities

And these shadows are vague and ill defined Heisenberg's uncertainty principle asserts that we can know accurately only about half of all measurable

quantities, and that an attempt to improve the precision of our knowledge of this half automatically interferes with our obtaining a like knowledge of the other half

Even space and time have become blended, as Minkowski tells us This involves the introduction of hypergeometry into the realms of physics, a thing utterly taboo not more than forty years ago

And Dirac has called into question the fundamental character of our number concept, suggesting that the really fundamental things of Nature are incapable of expression numerically, and that numerical relations begin to appear only when we reach combinations of these fundamentals of a certain degree of complexity

The remarkable thing about all this is that it is possible to cut more closely to Nature's lines by means of these shadowy concepts than was possible under the older materialistic régime (*Author's abstract*)

Discussed by Messrs. HUMPHREYS, HAWKESWORTH, WHITE and TUCKERMAN.

L V JUDSON, *Corresponding Secretary*

1025TH MEETING

The 1025th meeting was held in the Cosmos Club Auditorium, Saturday evening, October 10, 1931, President CURTIS presiding

Program F B SILSBEE *Composite coil instruments for precise a c measurements* (illustrated) —This paper describes a new type of electrodynamic instrument adapted for use in measuring alternating current, voltage, and power at the frequencies used in power circuits Both the fixed and moving coils are formed of separate windings insulated from each other One set of windings carries the alternating currents to be measured, while the other set carries direct current supplied by a 12-volt storage battery. The direct currents can be set by suitable control rheostats to that one of a series of definite values at which the torque produced by them is approximately equal and opposite to the a c torque Any unbalanced difference in torques causes a deflection of the moving coil which is read by the location of a line of light on the instrument scale The value of the direct current is obtained by comparing the drop in a known resistance with the voltage of a standard cell.

In this way the bulk of the quantity under measurement is referred directly to the standard cell and the errors in scale reading, spring fatigue, self-heating, etc , affect only a small part (2 per cent of full scale value) of the total indication The use of an astatic double system greatly reduces the effect of the earth's magnetic field and at the same time can be used to compensate for the otherwise large effects of mutual inductance between the a c and the d c windings Instruments of this type can readily be designed to have a precision of reading equivalent to that of an ordinary instrument with 1500 scale-divisions and still have a period of 3 5 seconds, and an accuracy approaching 0 01 per cent (*Author's abstract*)

Discussed by Messrs HAWKESWORTH, TUCKERMAN, GIBSON, and WHITE

W. P WHITE: *The insulation of thermels and other points of thermel technique* (illustrated) —Shortly after its introduction the highly sensitive copper-constantan or iron-constantan thermel (thermoelectric thermometer) gave results of outstanding precision in calorimetry But most of these were for short periods, and measurements with thermels over periods of an hour or more were found to show slight errors which were so frequent that they almost came to be regarded as normal After a good many years an attempt was made to investigate the sources of these errors with a view to removing them

There is every indication of success in this attempt, and if these indications are confirmed, the precision which can be relied upon will have been increased some ten-fold

Greater precision in the comparison temperature, which is always needed for reading single temperatures with thermels of any description, has apparently been obtained, although this part of the investigation is not completed Error from inhomogeneity of the wires has, by suitably locating the proper point for the temperature gradient, been reduced to 0 0001° in reading with an ice bath, and to a fraction of that when the comparison body is near the temperature of the other end of the thermel

The very highest insulation, 50,000 megohms or more, is desirable or necessary It can be obtained by drying out the thermel itself at about 120°, preferably by means of air, repeatedly pumped out, and then sealing the end of the glass inclosure where the leads emerge Two sealing compounds which do not show surface leakage even in a saturated atmosphere and which will remain dry under ordinary conditions, are picein and resin with 6 per cent of albolene

A convenient arrangement of the terminals outside this seal has been devised, which allows ready reversal both of the two halves of the thermel and of the connecting cable, thus detecting some of the very unlikely errors now remaining, should they occur (*Author's abstract*)

Discussed by Messrs KRACEK, STIMSON, and BRICKWEDDE

A B LEWIS: *A clock-controlled constant-frequency generator* (illustrated) — A synchronous motor generator set is described in which the motor is forced to rotate in synchronism with signals from a standard clock circuit This result is obtained by first running a specially wound motor synchronously from a 3-phase commercial power line The field of this synchronous motor is then electrically rotated about the motor frame by an amount which exactly compensates for the departure of the frequency of the commercial power from true 60 cycles This rotation of the motor field is produced by a rotary synchroscope, which is in turn controlled by thyratron tubes, the grids of which are excited by a clock-driven tuning fork The output of the generator is used to operate cycle counters, synchronous timers, or other light synchronous machinery

The possibilities and limitations of the machine are discussed and data are given to indicate the accuracy (± 0 004 sec) which may be expected from the machine when used as a timing device. Safety devices are described which shut down the machine should it for any reason fall out of synchronism with the clock signals or hunt excessively The machine has an ultimate load capacity of 4 kw and can take a suddenly applied load of 2 kw without serious hunting (*Author's abstract*)

Discussed by Messrs L H ADAMS, WHITE, KSANDA, SILSBEE, and GIBSON.

1026TH MEETING

The 1026th meeting was held in the Cosmos Club Auditorium, Saturday evening, October 24, 1931, President CURTIS presiding

The program was the occasion of the first Joseph Henry Lecture, in memory of the first President of the Philosophical Society of Washington

The lecture of the evening, *Certain aspects of Henry's experiments on electromagnetic induction*, was delivered by JOSEPH S. AMES, President of Johns Hopkins University (Published in this JOURNAL 21: 493)

1027TH MEETING

The 1027th meeting was held in the Cosmos Club Auditorium, Saturday evening, November 7, 1931, President CURTIS presiding

Program: C S. BARRETT· *Imperfection in crystals* (illustrated).—The X-ray reflecting power of a crystal depends on its perfection. If a rather perfect crystal be rendered imperfect at its surface by grinding, the X-ray reflection from these surfaces is much more intense than from interior points This may be shown by the nature of the spots on a Laue photograph. If a quartz plate be oscillated piezo-electrically, an unusual distribution of reflecting power results A study of this distribution shows that the reflecting power of a given atomic plane varies greatly from point to point in the crystal, while at a given point in the crystal the reflecting powers of different planes are affected differently This phenomenon differs from that resulting from grinding the surfaces Experiments indicate that the phenomenon in oscillating quartz is due to strain gradients, and that it affords a new means of analysis of modes of vibrations of quartz oscillators and resonators, and of inhomogenous strains in other suitable crystalline materials (*Author's abstract*)

Discussed by Messrs HAWKESWORTH and KRACEK

S B HENDRICKS *Group motions in solid molecular and ionic compounds* (illustrated) —Crystal structure determinations for sodium nitrate and ammonium nitrate indicate that the nitrate groups are rotating in these solids before the melting points are reached The excitation of group rotation is accompanied by abnormal changes in such properties as the specific volume, the heat capacity, and the crystal structure In the case of sodium nitrate the setting in of the rotation is gradual while in ammonium nitrate it occurs at polymorphic transition points

Group rotation occurs in the ammonium and substituted ammonium halides, and probably in the hydrogen halides It is also to be observed in a number of molecular compounds such as hydrogen, methane, and ethane (*Author's abstract*)

Discussed by Messrs BARRETT, L H ADAMS, CURTIS, KRACEK, and HAWKESWORTH

L B TUCKERMAN, in an informal communication, called attention to Arthur Eddington's article, *On the value of the cosmical constant* The following is an abstract of his remarks.

Many years ago Ernst Mach pointed out that in a thoroughgoing theory of relativity the mass of any particle would represent, not a property of its own, but its interaction with all the other particles in the Universe Einstein, as well as others, has emphasized this viewpoint but no explicit expression of it has previously been embodied in any of the forms of the general theory of relativity

In a recent number of the Proceedings of the Royal Society (Series A, Vol 133, No A822, pp 605–615) Eddington, by an argument based on relativity considerations, identifies the mass term $2\pi m\ c\ \alpha/h$ in Dirac's wave equation of an electron with $\sqrt{N}/R$ where N is the number of electrons in the universe, and R is the radius of the Einstein world

This in connection with the Einstein equations enables him to calculate the number of electrons in the universe, the radius of the universe and in consequence the nebular red shift in terms of quantities which can be measured in the laboratory He finds for the number of electrons in the universe

$$N = \frac{\pi^2 e^4}{4G^2M^2m^2}$$

and for the nebular red shift expressed as a speed of recession v per unit distance d

$$\frac{v}{d} = \frac{2}{\sqrt{3}} \frac{GMm^2c^3}{\pi e^4}$$

where e = the charge of an electron, m = the mass of an electron, M = the mass of a proton, G = the constant of gravitation, and c = the velocity of light

The value of the red shift calculated from the laboratory data on G, M, n and c gives

$$\frac{v}{d} = 528 \text{ km per second per megaparsec}$$

while the value found from astronomical observations ranges from 430 to 530 km per second per megaparsec according to different observers

It seems probable that this contribution of Eddington's will prove to be one of the foundation stones of the coming synthesis of the theory of the physical universe

1028TH MEETING

The 1028th meeting was held in the Cosmos Club Auditorium, Saturday evening, November 21, 1931, President CURTIS presiding

Program N H HECK *Background and history of investigation of strong earthquake motions* (illustrated).—While instruments to record strong earthquake motions were developed in China as early as 146 A D , and while a number of seismologists have been interested in this problem, it is only recently that, as a result of investigations in Japan and in the United States, such measurements have become a factor in the design of buildings and structures to resist earthquakes

The importance of the problem has steadily increased as regions subject to severe earthquakes have become centers of population with the resulting congestion of buildings, large and small, containing large numbers of people and valuable property and records Other structures such as bridges, dams, and water supply systems are of almost equal importance Engineers through investigations of earthquake effects and by testing models on shaking platforms have erected buildings intended to resist earthquakes but feel great need for actual observations of earthquake intensity

Prominent civil engineers visiting Japan at the time of the World Engineering Congress in 1929 became interested in this problem and the last Congress made an appropriation to the Coast and Geodetic Survey to develop instruments and make measurements of strong earthquake movements The instruments described have included a starting device, a three-component accelerometer, and two types of automatic recorders On account of paper cost the record must be started by the earthquake Through effective cooperation, the starting device has been developed by the Massachusetts Institute of Technology, the accelerometer by the Bureau of Standards, and the recorders by the Coast and Geodetic Survey The instruments have not yet been tested by an earthquake but have been severely tested on shaking platforms They give excellent promise of giving the desired results when installed in earthquake regions (*Author's abstract*)

FRANK WENNER. *Development of accelerometers at the Bureau of Standards* (illustrated) —In the design of buildings, bridges, etc , to have the maximum

resistance to earthquake shocks consistent with reasonable cost, the structural engineer needs fairly definite information concerning the probable ground movements in order to predict the forces to which various parts of the structures may be subjected Presumably the ground movement within the destructive area of major earthquakes, while decidedly irregular, is for the most part back and forth about an equilibrium position, and so may be considered as a series of superimposed, damped harmonic motions of various periods According to the experience of the Japanese, it is those components of the motions having periods of from one to three seconds which are mainly responsible for the destruction of property The only known means of obtaining records of these movements is by means of a seismometer, and it seems generally to be assumed that a seismometer should have a period approximately the same as that of the components of the ground movement considered most significant However, a seismometer having a period of from one to three seconds would give neither reasonably accurate records of the accelerations, of the velocities, nor of the displacements associated with ground movements having periods within this range, and consequently would give little if any data of value to the structural engineer If the period of the instrument were rather long, 10 seconds or more, reasonably accurate records of the displacements would be obtained, but on account of the irregularity of the movements such records would scarcely serve for a determination of the forces transmitted to structures On the other hand, a very short period instrument gives directly the accelerations, which must be known if the forces are to be calculated The instrument shown here, which is one of three constituting a set—one for each of the three perpendicular components of the ground movement—has a period of one-tenth second and is so damped that it gives reasonably accurate records of all accelerations which either remain constant for 0 04 second or more, or have periods of 0 15 second or more With the photographic recording paper at a distance of 50 cm from the mirror the displacement on the record is approximately 2 5 cm for an acceleration of one-tenth gravity The instrument is 12-1/2 cm high and has a mass slightly in excess of 1500 grams The steady mass of approximately 4 grams is supported by quadrifilar suspensions and has a reduced length of approximately one cm. The paper was illustrated by diagrams and a table showing the relations between accelerations of different periods and the corresponding displacements These will be reproduced in a paper to be published shortly in the Bulletin of the Seismological Society of America. (*Author's abstract*)

M W. BRAUNLICH: *The contact accelerometer as a starting device for use with a strong earthquake accelerometer* (illustrated, read by H E McCOMB) — The instrument consists essentially of a steady mass of about 200 grams mounted as an inverted pendulum on thin, steel springs and free to oscillate in one plane The steady mass is held away from its natural position of rest by a micrometer screw, the contact between screw point and steady mass being in a closed electrical circuit When the accelerations reach or exceed a certain predetermined value the contact is broken due to the inertia of the mass and a relay is operated which in turn closes or opens other circuits which may start the accelerometer recorder This particular type has the advantage over other mechanically operating types in that it is free from friction It is recommended that six of these accelerometers be used in series, orienting them in different directions and in the vertical in order to insure operation of at least one component regardless of the direction of the initial impulse Tests indicate that one of the instruments will get a recorder into operation in less than 0 19 second after the impulse (*Author's abstract*)

D. L. PARKHURST. *Automatic electric recorders* (illustrated).—The automatic electric recorder operates continuously. The drum carries photographic paper but there is no recording until the electric light is turned on by the starting accelerometer as described elsewhere. At the same time as the light, a time recording mechanism and a warning signal must be switched on. The recorder operates for half an hour and then stops automatically. Since many strong earthquakes have a single shock, arrangement is made to turn off the light after a few minutes, the record not resuming unless another earthquake occurs.

Cost is saved by making the recording drum from a commercial aluminum cooking kettle.

There are two driving motors, one an induction motor driven from the 110-volt lighting circuit and the other a direct current motor driven from a dry cell to operate in case the line current is cut off through the earthquake. Change from a.c. to d.c. and back is made without change of speed of drum. The needed gear reduction is accomplished by adding a third motor which runs idle and which is so built as to give the needed reduction.

Practically all the details are standard commercial articles and this reduces the cost, an important matter since the number of installations is considerable. (*Author's abstract.*)

H. E. MCCOMB. *An automatic-starting recorder with motor-clock drive for use with accelerometers* (illustrated).—A motor-clock-driven recorder has been developed for use in connection with the registration of records made by an earthquake accelerometer. It consists essentially of a commercial motor clock, equipped with ball governor, which drives a drum at the desired peripheral speed for about 20 minutes. Lamp and cylindrical lens are provided for use in photographic registration. The device is automatically started by means of suitable trigger devices operated by means of a Braunlich contact accelerometer. The recorder is well adapted for shaking table tests and has been used in testing accelerometers of different types. (*Author's abstract.*)

After presentation of the above papers there were discussions by Messrs. HECK, WRIGHT, WENNER, L. H. ADAMS, BLAKE, and CURTIS.

W. J. HUMPHREYS in an informal communication, *White lightning and red lightning*, stated that it is reported that white lightning starts more fires than red lightning and discussed the reasons why this should be true.

G. R. WAIT, *Recording Secretary.*

GEOLOGICAL SOCIETY

480TH MEETING

The 480th meeting was held at the Cosmos Club, October 28, 1931, President MEINZER presiding.

Program. PHILIP B. KING: *Permian limestone reefs in the Van Horn region of Texas.*—In the van Horn region of west Texas, Permian rocks make up the greater part of the mountain crests, and in places extend nearly if not quite to their bases. The combined thickness of the various partial sections of the series exposed in the different ranges is about 7000 feet. The series overlies all the older formations of the region, including rocks of Pennsylvanian age, with great unconformity. Deposition throughout the epoch was nearly continuous and undisturbed by diastrophism or incursions of clastic sediments. Uniform conditions persisted throughout long periods of time, so that there is an unusual development of different lithologic and faunal facies. Changes between facies are abrupt both laterally and vertically, giving rise, seemingly, to a variety of formations and faunas in each vertical section.

Recent work by J. B Knight and the writer leads to the conclusion that the controlling factor in the changes of facies was the persistent growth of long limestone reef barriers In Sierra Diablo and the Baylor Mountains, where the chief studies were made, such reefs extend through a stratigraphic section 3000 feet thick and have been traced for a linear distance of 30 miles The reefs are preserved as massive limestones and dolomites with irregular original dips, which contain a fauna of massive algae, sponges, bryozoa, and corals, as well as crinoids with large columns, and thick-shelled brachiopods To the northeast the reef beds interfinger in a short distance with black limestones and siliceous shales containing ramose and frond-like bryozoa, thinly shelled and spinose brachiopods, and a locally developed rich molluscan fauna; these strata were probably deposited in the open sea On the opposite or southwestern side, the reef limestones merge into thinly bedded dolomites abounding in fusulinids, which in turn give place to limestones and marls with a restricted fauna characterized by the abundance of a relatively few species of gastropods and brachiopods The beds behind the reefs are considered to be of lagoonal origin

These abrupt lateral changes from one facies to another are particularly confusing in stratigraphic work because the lagoonal faunas are so conservative that they have often been assigned to a Pennsylvanian age, whereas the open sea faunas, even near the base of the Permian have a decidedly Guadalupian aspect Future attempts to classify the Permian must recognize the profound influences of facies on the faunas, and a search must be made for fossils of limited vertical and wide horizontal range The most promising groups for purposes of classification now appear to be the ammonoids and the fusulinids (*Author's abstract*)

Discussed by Messrs GOLDMAN, CAPPS, and FERGUSON

F C CALKINS *Petrography of drill cuttings from saline deposits.*

Discussed by Mr GILLULY

ROBERT VAN V ANDERSON *Geology in the coast ranges of Western Algeria* — The Atlas ranges and intervening plateaus of northern Algeria represent a somewhat elevated, wrinkled and in part broken, less stable fringe, some two hundred miles wide, along the more stable continental mass farther south Of this fringe the Tell Atlas, or Mediterranean Coastal ranges, occupying a belt about fifty to seventy-five miles wide on the north, form a zone of greater instability, in which a larger amount and the latest accretions of deformation have taken place The rocks are mainly Jurassic, Cretaceous, and Tertiary marine sediments, with scattered outcrops of more ancient strata, the latter appearing especially adjacent to the coast

The whole French north African continental border was uplifted in the post-Eocene Alpine revolution, but portions of the Tell Atlas belt were later subjected to repeated submergence beneath the sea, reemergence and folding. The Miocene-Pliocene marine section comprises a thickness of over ten thousand feet The principal epochs of emergence and deformation in the later Tertiary were after the early Miocene, to a lesser extent after the late Miocene, and again during and after the Pliocene The present structural and topographic forms in the coastal ranges of western Algeria are essentially of Quaternary origin and modification The superficial crustal movements in these coast ranges have been to a considerable extent in the nature of local warping and compressional folding, with faults more in the nature of readjustments than as primary structural forms (*Author's abstract*)

Discussed by Messrs STOSE, HESS, HEWETT, GOLDMAN, ALDEN, ATWOOD, and STEPHENSON.

481ST MEETING

The 481st meeting was held at the Cosmos Club, November 11, 1931, President MEINZER presiding

Informal Communications H D. MISER reported the rediscovery of mercury ores recently near Murfreesboro, Pike County, Arkansas The ore occurs in cracks in sandstone but does not impregnate it. The ore is cinnabar with minor amounts of native mercury, quartz, and dickite

C S ROSS.—Associated with the cinnabar in Pike County, Arkansas, is the clay mineral dickite of the kaolin group Dickite is always of hydrothermal origin and its association with the mercury ores throws light on their origin

Discussed by HESS

R C WELLS reported the discovery of the new element number 87 This element belongs to the alkali group and was extracted from the mineral samarskite by Dr Rapisch of Cornell Uiversity.

Regular Program F E MATTHES—*Walter Penck's concept of the "Primary Peneplain (Primarrumpf)"*

Discussed by Messrs MEINZER, MERTIE, and CAPPS

JAMES M HILL· *A problem of beryllium ores*—Within the last three years, or since 1928, there has developed a limited market for commercial beryl as distinct from gem material The commercial beryl should contain not less than eight to ten per cent BeO, and at the present time is quoted at about $50 00 a ton This demand arises from the discovery that a small quantity of beryllium added to aluminum and aluminum-magnesia alloys gives a surprising strength and corrosion resistance to the resulting metal It appears that these beryllium-aluminum alloys will have a wide use in airplane construction and in several other industries where lightness and great strength are required The chief markets are in Germany and the United States In this country the Beryllium Development Corporation has acquired practically all of the patent rights covering the production of chemical beryllia (BeO) as well as the patents covering the various alloys This company has expended considerable money in research work during the past three years and is now endeavoring to obtain a supply of beryl

So far as I know, beryl occurs only in pegmatite lenses and the chief production in the past has come from the New England and Piedmont states in the east and the Black Hills in the central part of the United States There are some properties in the Union of South Africa worked primarily for gem beryl that are producing and shipping commercial beryl to both Germany and the United States It was my privilege to examine several pegmatite deposits in the far west during 1929 with a view to obtaining a commercial supply of beryl and it seems reasonable to believe that several of these deposits can produce Probably no one mine can supply more than a few tons of beryl a day at best, and in most of them the production will be of the order of a few tons a week or month

My examinations showed that besides the beryl crystals, which can be hand sorted, there is in some deposits as much as sixty per cent of the total BeO content of the rock in the form of very finely divided beryl mixed with quartz and feldspar Such material could not be hand sorted and wet concentration methods are impossible because all of the minerals have approximately the same specific gravity In some experimental work I did, looking for a method of separation of the material, I was able to recover fifty to seventy-five per cent of this fine beryl in a flotation concentrate that contained from ten to as much as twelve per cent BeO All of my work so far has been

on a laboratory scale and there are many kinks in the metallurgy which will have to be ironed out in commercial practice. I believe that to obtain an adequate supply of beryl it will be necessary to operate a considerable number of mines on a relatively small scale at each place and that surely some form of metallurgy will have to be used in order to get as much of the beryl content of the ore as possible Most of these deposits will have to be operated for either quartz, feldspar or mica, and the beryl will be a valuable by-product. I have seen no deposits as yet which I believe can be operated for beryl alone. (*Author's abstract*)

Discussed by Messrs STEIGER, SCHALLER, SCHAIRER, R C WELLS, and HESS

G. R MANSFIELD: *Further developments in the geology of southeastern Idaho* — Areal geologic maps (on the scale of 1 62,500) of the Ammon and Paradise Valley quadrangles, the latest for which field work has been completed in south-eastern Idaho, were exhibited together with adjoining published maps on the same scale. The northwest extension into these quadrangles of formations and structures observed in the previously mapped areas was noted and the relation of Tertiary beds and lavas to earlier formations and structures was pointed out. The general relations of the Bannock overthrust were discussed and a number of windows at distances ranging from 9 to 25 miles back from the front of the upper fault block were described Comparison was made with the Turner Valley area in southern Alberta, Canada, where, according to Moore and Link, an anticlinal structure in Upper Cretaceous beds and containing deep-lying, oil-producing Madison limestone has been shown by drilling to be overthrust at depth on beds of Upper Cretaceous sandstone. The interpretation offered by these authors for this area is that of a low angle thrust plane or sole accompanied by steeper subsidiary longitudinal faults This interpretation is thought to add confirmatory evidence to the similar interpretation earlier made by the writer for the Bannock overthrust in southeastern Idaho (*Author's abstract*)

Discussed by Messrs HESS, BUTTS, KING, PARKER, MISER, HEWETT and GILLULY

C H. DANE, J. F SCHAIRER, *Secretaries.*

Obituary

The death in Washington on April 12, 1932, of LOUIS AGRICOLA BAUER, the original Director and, since 1930, Director Emeritus of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, removes from science an internationally recognised authority in the field of his special interest. Almost solely on account of his enthusiasm and organizing ability, the systematic magnetic survey of the whole Earth, both on land and on the oceans, has been accomplished within the past twenty-five years This survey established an empirical basis for theoretical discussions of the origin and behavior of the Earth's magnetic field which would otherwise have long remained impossible While the recognition accorded Dr Bauer rests largely on this monumental achievement, he was also among the foremost in the discussion of not only terrestrial magnetism but of other related geophysical problems, as is evidenced by the long list of titles with which he is accredited.

Born of German-American parentage on January 26, 1865, in Cincinnati, Ohio, Dr. Bauer received from the University of Cincinnati the degrees of Civil Engineer (1888) and Master of Science (1894) After a short experience as computer in the Coast and Geodetic Survey under Mendenhall and

Schott, his interest in terrestrial magnetism was aroused and he entered the University of Berlin There he came under the influence of the men whose names are inseparably connected with the progress of geophysical science of that period The subject of his dissertation for the degree of Doctor of Philosophy obtained in January 1895 at Berlin was indicated in the title, *Beiträge zur Kenntniss des Wesens der Säkular Variation des Erdmagnetismus*

On his return to America he served successively on the faculties of the universities of Chicago and Cincinnati When the Division of Terrestrial Magnetism was established at the Coast and Geodetic Survey in 1899 he was made Inspector of Magnetic Work and Chief of Division In 1904 he became Director of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, founded as the result of his efforts During the following twenty-five years the carrying out of this ambitious project was vigorously prosecuted under his able and zealous leadership Its work has already splendidly realized his vision

Dr C Dwight Marsh, a retired research worker of the Bureau of Animal Industry, died unexpectedly on April 23, 1932 He was born in Hadley, Massachusetts, December 20, 1855 He graduated from Amherst College in 1877, and was awarded the degree of doctor of philosophy by the University of Chicago in 1904 After graduation, Dr Marsh spent about a year at the Marine Biological Laboratory at Woods Hole, Mass , and then entered the teaching profession He was professor of biology at Ripon College, Wisconsin, for 20 years, serving also as dean of the college during the latter part of this period He was responsible for the development of the Wisconsin Academy of Sciences, Arts, and Letters and served as president for one term From 1905 until his retirement a few years ago, Dr Marsh was associated with the U S Department of Agriculture

Dr Marsh was a member of the Phi Beta Kappa, the Washington Academy of Sciences, and the Cosmos Club Some of his most important scientific work relates to the study of plankton life in fresh-water lakes and to the discovery of the effects of poisonous plants on animals

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ENGINEERING.—*The work of Joseph Henry in relation to applied science and engineering.*[1] ARTHUR E. KENNELLY.[2] (Communicated by L. B. TUCKERMAN.)

The pioneer work of Joseph Henry in physics, and especially in its department of electromagnetics, has justly claimed the principal attention of his biographers and students. Certain aspects of Henry's work in the physics of electromagnetic induction were the theme of that fine presentation last year by President J. S. Ames of the Johns Hopkins University, in the first Joseph Henry lecture of this series. Henry also accomplished, however, so much in applied physics, that without detracting in the least from his fame as a pure scientist and researcher in basic physics, it seems proper to consider, at this time, his achievements in relation to applied science and engineering.

As it is sometimes difficult to distinguish between basic and applied science, when considering the manifold occupations and accomplishments of a scientific pioneer like Henry, we may be permitted to consider as basic those scientific studies directed to the development of a field of knowledge *per se*; and as applied science or engineering, those studies directed to utilities, as well as to the field itself. So interwoven, however, are basic and applied science, and especially in physics, that the distinction between them may sometimes be reduced to mere differences in the attitude of the researcher's mind One and the same piece of scientific research may be regarded as either basic, or applied, or both, according as the researcher directed his mind to the field of knowledge itself, or to its utilization, or to both.

[1] An address, the second Joseph Henry lecture, delivered before the Philosophical Society of Washington on April 23, 1932 Received April 25, 1932

[2] Professor Emeritus of Electrical Engineering, Harvard University and the Massachusetts Institute of Technology

Henry's accomplishments in applied science are notable in the following fields:

I. Civil Engineering.
 Surveying and Geodetics
II. Electrical Engineering
 (a) Lifting electromagnets
 (b) Electromagnetic telegraphy
 (c) Elementary electromagnetic motors
 (d) Lightning protection
 (e) Electroballistics
III Mechanical Engineering
 (f) Building stone tests
IV Acoustical Engineering
 (g) In buildings
 (h) In fog-signalling
V Illumination Engineering
 (i) In light-house development
VI. Meteorological Engineering
 (j) Forecasting from telegraph bulletins.

It may be noted that among the 148 publications appearing in the *List of Professor Henry's Scientific Papers*, printed in the Annual Report of the Smithsonian Institution for 1878 and the Bulletin of the Philosophical Society of Washington, Vol II, nearly forty relate to scientific applications.

SURVEYING AND GEODETICS

In 1825, New York State appointed commissioners to survey the route for a state road from the Hudson River to Lake Erie, a distance of over 500 km Henry was appointed an engineer on this survey The route he followed was from Kingston, near West Point, on the Hudson, to Portland Harbor on Lake Erie. He acquitted himself so well in this survey, that an effort was made to have him appointed permanently as state engineer. In 1829, he read a paper,[3] published in the Transactions of the Albany Institute, which is a topographical report covering a considerable part of the state of New York, giving tables of distances and elevations along various routes. His paper gives a clear description of the topography of the country along these routes. It states:

> "The elevations in Table No. 1, between the Hudson River and Bath, are from the survey of William Morell, Esq The remaining elevations of this Table, as well as those in No. 2, are from the personal survey of the writer of this article "

[3] *Topographical sketch of the State of New York designed chiefly to show the general elevations and depressions of its surface* Bibliography 8, I: 8–36 Trans Albany Inst, I: 87–112 The bibliography is at the end of the paper

These levelling surveys had to be carried over some very difficult stretches of country, including sections of what was, at that time, primeval forest Henry seems to have taken so much interest in this work that it may have been a matter of good fortune for both basic and applied science, when he was diverted from the profession of engineering by the vacancy of the Chair of Mathematics and Natural Philosophy in the Albany Academy.

ELECTRICAL ENGINEERING

The Traction or Sustaining Electromagnet

Sturgeon, in England, had announced, in 1825, the production of the first horse-shoe electromagnet. It consisted of a bar of soft iron bent into horse-shoe form, insulated on its surface by a coat of varnish,

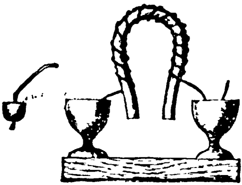

Figure 1 —Sturgeon's electromagnet

and with bare copper wire wound over it in separate spires When a voltaic current was passed through the copper wire, the horseshoe became magnetized, and would lift an iron rod laid across its poles.

The laws controlling the force of attraction between the electromagnet and its soft iron keeper, or armature, are complicated and were not worked out in detail for practical applications until many years later. They involve a combination of electric current in the electric wire circuit and of magnetic current or flux in the magnetic circuit.

Henry, experimenting with electromagnets at Albany, N. Y. in the years 1828–1831, succeeded in establishing certain fundamental principles, as to the conditions in both the electric and magnetic circuits, for securing the maximum attractive force from a given horseshoe electromagnet. At the same time, he greatly improved the winding on the magnet by using insulated wire in many close turns. At that time, of course, there were no instruments for measuring electric

current. He made a series of electromagnetic measurements with three controlled elements, viz

(a) the number and the size of the voltaic cells in the exciting circuit of the electromagnet,
(b) the length of extra copper wire introduced into this circuit,
(c) the number of series or parallel windings on the electromagnet.

Under these controlled variations, he measured the attractive force, in pounds weight, exerted by the magnet

In cooperation with Dr. Ten Eyck, he showed, from a number of such measurements, that the greatest attractive force or lifting power[4] could be obtained from a horseshoe electromagnet by the use of a "quantity battery" together with a "quantity winding" on the magnet, provided that the battery and magnet were close together and connected by short lengths of wire. That is, the battery should have only one cell and its plates should be of large surface. The magnet windings should be connected in parallel. On the other hand, when the battery and magnet were far apart and had to be connected by a long wire, the best arrangement for attractive force on the armature was to use an "intensity battery" and an "intensity magnet," i.e. the cells of the battery should be connected in series, and also the windings of the magnet He points out that this combination has a bearing upon the problem of an electromagnetic telegraph If, however, an intensity magnet has to be used, with all its turns in series, then for best tractive effort an intensity battery should be placed in the circuit, whether the connecting wires between them are short or long.

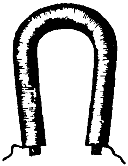

Figure 2 —Henry's intensity electromagnet

All of these principles, enunciated by Henry, more than a hundred years ago, are still fundamentally correct The terminology, however, has been greatly changed, partly through the widespread knowledge of Ohm's law ($I = E/R$) of current in an electric circuit Dr. Ohm had already published, in Berlin, his essay containing that law[5] in 1827, but the publication received very little attention, and did not find its way into text books on physics until some twenty years later. It did not come into electrical applications until after 1840, in the early de-

[4] Bibliography 8, I: 37-53 Silliman's Am Jour Sci 19 400-408 Jan 1831

[5] *Die galvanische Kette mathematisch bearbeitet* Georg Simon Ohm, Professor of Physics at Munich, Berlin 1827.

velopment of telegraphy, and after instruments had been produced for measuring electromotive force, resistance, and current. The above mentioned results which Henry published in 1831, were far in advance of the knowledge in electromagnetics at that time.

In one set of measurements he describes his electromagnet as made of a cylindrical bar of soft iron 1/4 inch (0.64 cm.) in diameter, wound with about 8 feet (2.4 m) of insulated winding with perhaps 100 turns. When this winding was excited by one copper-zinc voltaic cell with plates of 28 sq. in. (180 sq. cm.) immersed in dilute acid, the weight lifted by the magnet was 4½ lbs. (2 kg.). When a length of 1060 feet (320 m.) of copper bell wire 0 045 inch (1.14 mm.) in diameter was inserted in the circuit between voltaic cell and magnet, the lifting power of the magnet fell to about half an ounce (14 gm) The resistance of the length of copper specified would today be about 8 8 ohms, but at that date, when high-conductivity copper was not in demand, it may readily have been nearly 20 ohms

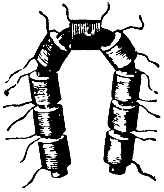

Figure 3 --Henry's electromagnet with group coils, for connection either in series or in parallel

With an intensity battery of 25 zinc-copper cells in series and with the same active area of plate surface in each cell as before, the magnet lifted 8 ounces (227 gm.), with the whole length (320 m.) of copper wire inserted in the circuit, so that changing from 1 cell to 25 cells, increased the lift from 14 gm. to 227 gm, with the whole length of wire included. Short circuiting the long copper wire, or connecting the 25-cell series battery to the magnet terminals, gave no increase in lifting power Indeed the lifting power observed was somewhat less (7 oz. or 198 gm) It will be remembered, however, that the plain zinc-copper battery of those days was subject to marked polarization and variation of electromotive force, while in action The effect of changing the battery from one cell to 25 in series, increased the lift from 14 gm to 227 gm., with the long wire in circuit, but with the long wire cut out, the lift fell from 2,000 gm. to 227 gm. This was the first published demonstration of the importance of using a series-connected, or intensity battery, to increase the tractive power of an electromagnet of many turns through a considerable length of external circuit

Discussing the remarkable power of the intensity battery to overcome the effect of inserting the 320 meters of extra copper wire in the circuit, Henry remarks:

> "On a little consideration, however, the above result does not appear so extraordinary as at first sight, since a current from a trough possesses more 'projectile force' to use Prof Hare's expression, and approximates somewhat in intensity to the electricity from the common machine. May it not be a fact that the galvanic fluid, in order to produce its greatest magnetic effect, should move with a small velocity? From these experiments it is evident that in forming the coil we may either use one very long wire, or several shorter ones as the circumstances may require, in the first case our galvanic combinations must consist of a number of plates so as to give 'projectile force', in the second it must be formed of a single pair."

Here Henry uses the term "projectile force" to designate what we call today *electromotive force* and "velocity of magnetic fluid" for

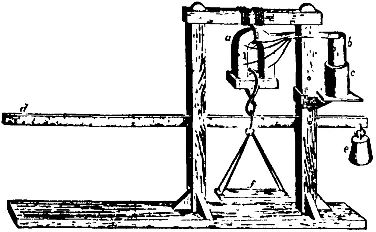

Figure 4.—Henry's frame for testing strength of electromagnet

what we now call *current strength*. He is evidently not far from a conception of Ohm's law, which had already been formulated mathematically by Ohm four years before. By the term "trough" in the above quoted passage, Henry evidently means a series-connected battery, with the elements arranged in the form of a trough. Also by the term "common machine" he doubtless refers to either the frictional or the induction electric machine, which were the only electric generators known, prior to Volta's discovery, in 1800, of the voltaic pile.

In the same publication, Henry goes on to describe the construction of a larger electromagnet, a model of which, kindly loaned to us by the Smithsonian Institution from its museum, is shown here this evening.

The magnet had a winding of 9 coils of insulated copper wire arranged to be connected either in series or in parallel combinations. The total *weight of the magnet was 21 pounds (9.5 kg). It was* excited by one zinc-copper dilute acid cell with concentric plates. The effects were tried of various winding combinations on the sustaining power of the magnet. The maximum was reached at 750 pounds (340 kg.), when all the windings were connected in parallel, or as a "quantity" winding The magnet thus lifted more than 35 times its own weight, with the aid of a single exciting cell, a very remarkable achievement for the year 1831.

In a communication to Silliman's American Journal of Science[6] in April 1831, Henry describes a yet larger horseshoe electromagnet,

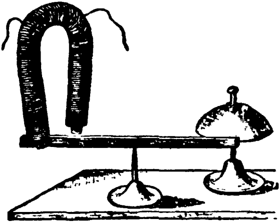

Figure 5 —Henry's bell-signal electromagnet

constructed for Yale University. It weighed 59½ pounds (27 kg) without its multiple-coil winding. Excited with a single zinc-copper dilute acid cell, it supported a weight of 2063 pounds (937 kg)

Electromagnets for raising and carrying masses of iron are in fairly extended engineering use at the present day, and Henry's pioneering work at the Albany Academy from 1827 to 1832 clearly pointed the way to that electrical application

The electromagnetic bell signaling instrument here shown, from the Smithsonian Museum collection of Henry apparatus, is a replica of an apparatus made and used by Henry, in 1832, for sending audible electromagnetic signals through a wire more than a mile in length. This apparatus is not referred to in Henry's paper of 1831, but appears in Henry's statement to the Board of Regents of the Smithsonian Insti-

[6] *An account of a large electromagnet, made for the laboratory of Yale College* Bibliography 8, I· 50–53

tution for 1857, together with testimony to show that the instrument was exhibited in 1832, at the Albany Academy.[7]

"I arranged around one of the upper rooms in the Albany Academy a wire of more than a mile in length, through which I was enabled to make signals by sounding a bell (Fig 7.)* The mechanical arrangement for effecting this object was simply a steel bar, permanently magnetized, of about ten inches in length, supported on a pivot, and placed with the north end between the two arms of a horse-shoe magnet When the latter was excited by the current, the end of the bar thus placed was attracted by one arm of the horse-shoe and repelled by the other, and was thus caused to move in a horizontal plane and its further extremity to strike a bell suitably adjusted "

* Here Fig 5

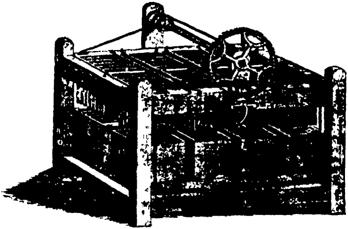

Figure 6 —Henry's voltaic battery for speedy change of connections between series and parallel

The original Henry instrument is kept in the Palmer Laboratory Museum at Princeton, where Henry set it up, and is reported on good authority to have been used as a signalling device, in his house, on the Princeton University campus, operated by electric current from his laboratory, probably in the basement of Nassau Hall

Henry declared that he never in his life filed an application for a patent of invention. In this technical sense, therefore, he was not an inventor; but in a broad sense of the term, he was undoubtedly a great inventor; because in making researches in basic science—his selected field of work—he often indicates through his writings that he realized from time to time possible applications for his discoveries, while leaving to others the tasks of introducing them into industrial

[7] *Statement in relation to the history of the electro-magnetic telegraph* Smithsonian Annual Report for 1857, pp 90–106 Bibliography 8, II: 420–437

service. He always admitted that Morse was the inventor of the electric telegraph bearing that name, but Henry has recorded the following claims:[8]

"From a careful investigation of the history of electromagnetism in its connection with the telegraph, the following facts may be established

(1) Previous to my investigations, the means of developing magnetism in soft iron were imperfectly understood, and the electro-magnet which then existed was inapplicable to the transmission of power to a distance

(2) I was the first to prove by actual experiment that in order to develop magnetic power at a distance a galvanic battery of 'intensity' must be employed to project the current through the long conductor and that a magnet surrounded by many turns of one long wire must be used to receive the current

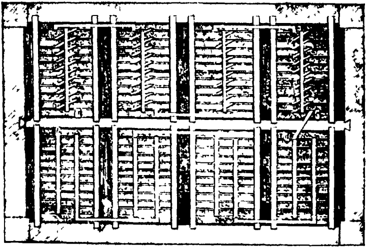

Figure 7 —Plan view of battery

(3) I was the first to actually magnetize a piece of iron at a distance, and to call attention to the fact of the application of my experiments to the telegraph

(4) I was the first to actually sound a bell at a distance by means of the electro-magnet

(5) The principles I had developed were applied by Dr Gale to render Morse's machine effective at a distance "

There can be no doubt that Henry's electromagnetic researches found abundant application in the magnetic telegraph.

Voltaic-Battery Mechanism for Series-Parallel Connections

Henry published in 1835, an illustrated description of a machine which he designed and constructed at Princeton for swiftly changing

[8] Bibliography 8, II. 435-436

a voltaic battery of 88 cells, from series to parallel combinations, so that they might be, in the extreme cases, either all in series or all in parallel.[9] The various pairs of plates were held in a rigid wooden frame, and each plate had a little metallic cup fastened to it for holding a small quantity of mercury. Metallic bars of suitable size and shape, served to connect the cells in series or in parallel.

The same plan in essentials, is very generally employed today with storage-battery installations for charging them in parallel and discharging them in various series combinations for high-tension service.

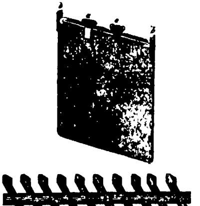

Figure 8 -- Henry's voltaic cell and connectors

Henry's apparatus was thus a pioneer form of voltaic-battery engineering design

Electromagnetic Engine or Early Form of Electric Motor

On the table, is the replica of Henry's early form of reciprocating motor driven by voltaic-battery power. This replica is also loaned by the Smithsonian Museum. The original is preserved with the Henry apparatus at Princeton University

The little engine is described by Henry in a letter to the Editor of

[9] *Description of a galvanic battery for producing electricity of different intensities* Bibliography 8, I· 80-86 Trans Am Phil Soc, 5. 217-222 Jan 1835

Silliman's American Journal of Science[10] published in July 1831, in the following terms.

"Sir: I have lately succeeded in producing motion in a little machine by a power, which, I believe, has never before been applied in mechanics—by magnetic attraction and repulsion

Not much importance, however, is attached to the invention since the article, in its present state, can only be considered a philosophical toy, although, in the progress of discovery and invention, it is not impossible that the same principle, or some modification of it on a more extended scale may hereafter be applied to some useful purpose But without reference to the practical utility, and only viewed as a new effect produced by one of the most mysterious agents of nature, you will not, perhaps, think the following account of it unworthy of a place in the *Journal of Science* "

The apparatus consists of a pair of vertical permanent magnets, which, in modern parlance, are the *field magnets* of the little machine.

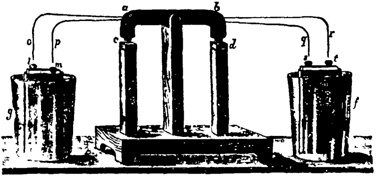

Figure 9 - Henry's electromotor device

As described in the paper, their north poles are uppermost A soft iron bar, pivoted about a horizontal axis, and wound with insulated wire, is free to oscillate over a certain range under the magnetic forces of the upright permanent magnets This oscillatory electromagnet corresponds to the *armature* of a modern direct-current motor At the free ends of the rocking armature are stiff projecting copper wires, arranged to dip into mercury cups at each end in such a manner that the current from a voltaic cell is caused to reverse the magnetization of the rocker bar near the end of each stroke, and so reverse the magnetic forces on the rocket bar In this rocking commutator, we have the precursor of the *rotating commutator* of the modern motor

Henry thus produced what was probably the first electric motor device using a commutator, although in the progress of the art, its

[10] *On a reciprocating motion produced by magnetic attraction and repulsion* Bibliography 8, I 54-57

reciprocating motion had to be converted into rotary motion, before practical success was attained with motors.

Lightning Protection

Henry was a close observer of atmospheric electric phenomena, and contributed a number of articles to the literature of the subject at different times. He also, however, formulated a set of rules or directions[11] to be followed for the protection of houses from lightning. These rules would probably be regarded as good engineering specifications against lightning damage at the present date.

Electro-ballistics

In 1843, Henry communicated to the American Philosophical Society, a paper[12] *On a new method of determining the velocity of projectiles.* He describes a chronograph drum, revolving at a uniform speed of at least 10 turns per second, so as to permit of high-speed ballistic records upon its surface. Two copper wire screens are placed successively in the path of the projectile whose speed is to be measured. The projectile cuts the wire in the screens so as to interrupt a voltaic circuit through each, at the instant of its passage. These circuit interruptions are automatically recorded on the surface of the drum, either by the deflection of magnetic needles, or by electric sparks puncturing a sheet of ruled paper on the drum. The sparks are caused by induction coils

The method and system, as described, constitute an electrical-engineering invention in ballistics.

MECHANICAL ENGINEERING

Testing of Building Materials

In August 1855, Henry read a paper before the American Association for the Advancement of Science, *On the mode of testing building materials* The President of the United States had appointed a commission of five persons in 1851, "to examine the marbles which were offered for the extension of the United States Capitol" at Washington. Another commission of three persons was appointed in 1854, to repeat and extend some of the experiments. Henry was a member of both commissions and evidently took upon himself a large share of the experimental work.

Small cubical blocks of the marbles to be compared were tested in a

[11] *Construction of lightning rods* Bibliography 8, II: 398–402, 1859 Also *On the protection of houses from lightning* Proc Am Phil Soc, June 20, 1845

[12] Bibliography 8, I: 212–215 Proc Am. Phil Soc, 3: 165–167 May, 1843

press for resistance to crushing. A long series of tests, made in this manner, brought out some remarkable and unexpected results. It was shown that when the crushing stress was exerted on the blocks with thin sheets of lead inserted between the press plates and the pressed block surfaces, the blocks gave way at about half of the pressure they could sustain when the lead sheets were not used. The account is, in effect, an engineer's report.

ACOUSTICAL ENGINEERING IN BUILDINGS

In the Proceedings of the American Association for the Advancement of Science[13] for August 1856, Vol X, pp. 119–135, Henry published a remarkable paper, *On acoustics applied to public buildings*. He states that Prof Bache and he had directed attention to the subject of acoustics as applied to buildings, when the President of the United States had referred to them the plans for the construction of rooms in the new wings of the Capitol at Washington They visited, with this object, the principal halls and churches in Philadelphia, New York and Boston The final plans of the new rooms were approved and successfully built

They also had designs prepared for the new lecture hall of the Smithsonian Institution, and incorporated into them various acoustic principles their researches had brought out These researches are most interestingly described in the paper. Henry, in this research, was an acoustical engineer, with his aim directed on improving the acoustic properties of the lecture hall He was, however, also a pioneer investigator of interior acoustics, considered as a basic science. He says (p 419)

> "These researches might be much extended, they open a field of investigation equally interesting to the lover of abstract science and to the practical builder "

In this passage is revealed that remarkable duality of Henry's mind which appears again and again in his writings. He studies a subject for a utilitarian purpose as an engineer, and enriches its basic science, while at another time he studies a new field as a physicist, and suggests intuitively to the reader where practical applications are likely to be found. He was *par excellence* a combination of physicist and engineer.

The acoustic properties of the Smithsonian lecture hall appear to have been very satisfactory, and to have endorsed the special acoustic features introduced into its construction

[13] Bibliography 8, II 403–421

FOG-SIGNAL ACOUSTICS

Congress established the U. S. Lighthouse Board in 1852, with Henry as one of its members. Later, as chairman of its Committee on Experiments, he directed, in 1865, a series of acoustic researches on fog signals, that were not only of basic scientific importance, but also of great engineering value. He showed experimentally that beyond relatively short distances, artificial sound reflectors were of no avail. To eliminate the personal equation in acoustic observations of this kind, he describes an artificial ear or "phonometer," for making feeble sound waves perceptible to the eye

These researches of Henry appeared as unsigned reports of the Light-House Board, but were subsequently included in his published papers. These reports contain comparisons of the acoustic ranges attained, under normal atmospheric conditions, by steam whistles, trumpets, and sirens. Such comparisons were made over short ranges by phonometer, and over long ranges by ear, on small vessels making exploratory trips for purposes of the test They are acoustic-engineering reports of great interest. They were made at various times from 1865 to 1877

In the course of these tests, Henry closely investigated the abnormal conditions of the appearance of fog signals at shorter and longer ranges, with their concurrent disappearance over a certain intermediate range, or belt of silence. These occasional but practically important acoustic anomalies, were referred to by Henry in two presidential addresses before your Society, one[14] on December 11th, 1872, when Dr. Tyndall was present, and the other[15]—his last address to you—on November 24th, 1877

ILLUMINATING ENGINEERING

Light-House Development

In the Report of the Light-House Board for 1875, pp. 86–103, Henry points out that in 1852, when the Board[16] commenced its operations, sperm oil was the fuel generally employed The steadily rising cost of sperm oil made it desirable to find some less expensive substitute. A series of experiments was commenced with lard oil, which

[14] *Remarks on some abnormal phenomena of sound* Smithsonian Report 1878, pp 490–496

[15] *The method of scientific investigation and its application to some abnormal phenomena of sound* Bull Phil Soc Washington, 2 162–174

[16] Bibliography 8, II. 477–510

was then much cheaper, but not regarded as capable of use in powerful lamps.

Commencing with a pair of small conical lamps having "single-rope," as distinguished from tubular wicks, one burning sperm oil and the other lard oil, the two commenced nearly at equality of candlepower, by photometer; but after burning for three hours the lard-oil lamp fell to about one-fifth of the photometric power of the sperm-oil lamp On analyzing the reasons for the falling off in candlepower of the lard-oil flame, Henry was led to the conclusion that the capillary flow or liquidity of the lard oil in the wick is relatively defective. This, however, was found to be affected by the temperature of the oil, so that by raising the temperature of the lard oil to about 250°F the liquidity of the lard oil became greater than that of the sperm oil When, therefore, the conditions of oil feeding through the wick of a large burner raised the temperature sufficiently, the lard oil should be capable of competing on favorable terms

After further preliminary trials with larger tubular-wick burners, the experiment was carried to Cape Ann, Massachustts. Here were two twin light-houses, only 275 meters apart. One of these was operated with sperm oil, as usual, and the other with lard oil, each lamp being so trimmed as to exhibit its greatest capacity

> "It was found by photometric trial that the lamp supplied with lard oil exceeded in intensity of light that of the one furnished with sperm oil The experiment was continued for several months, and the relative volume of the two materials carefully observed The quantity of sperm oil burned during the continuance of the experiment was to that of lard oil as 100 is to 104 "

A long series of photometric measurements at Boston is then described, with the substitution of the Bunsen grease-spot photometer head for the earlier Rumford shadow comparator. An improved photometer for measuring the candlepowers of burners using different oils, was also set up at the Smithsonian Institution

As a result of improvements in lamp mechanism, as well as in the substitution of lard oil for sperm oil in all of the light-houses of the United States, a great reduction was effected by 1866, in the annual cost of light-house oil.

This published account of light-house research is a fine engineering report, containing many basic scientific suggestions of great interest. Later on, the price of lard oil began to rise and a new series of researches was undertaken leading to the introduction of mineral oil, which was attended at first by a number of special difficulties

METEOROLOGICAL ENGINEERING

Applications of Telegraphy

In our daily contact with the service of the Weather Bureau, which displays coastal storm warnings in advance of expected heavy gales, and furnishes daily weather forecasts, with maps, showing the principal meteorological conditions, at a given hour each day, over the North American Continent, it is hard for us to realize the corresponding conditions that existed, say, in 1845, before Henry left Princeton, and when there was no way of foretelling the approach of a coming big storm, except such as could be guessed by any single observer at one spot, and before the general laws of revolving storms had been arrived at.

Henry devoted much time to the study of meteorology, which evidently exerted a fascination for him throughout his life. The first page of his published papers gives abstracts of his first known scientific contributions (Proceedings of the Albany Institute in 1825 and 1826)—communications dealing respectively with *Chemical and mechanical effects of steam* and *Refrigeration by rarefaction of air*. Among his published papers are 38 that bear by title upon meteorology According to the account by his biographer, W B Taylor, read before this Society October 26th, 1878, Henry's last feeble utterance on his dying day, May 13th, 1878 was a meteorological[17] enquiry.

Henry's early studies of weather, when he was at Albany, convinced him of the importance of securing simultaneous observations of barometric pressure, air temperature and humidity, wind velocity, cloud conditions and precipitation, at as many different stations as possible In 1849, while the telegraph system of the country was only a few years old, it was organized with the aid of voluntary observers into a network by which a weather map could be made up each day at the Smithsonian Institution Henry urged that every telegraph operator, coming on duty at a certain morning hour, should open with a definite meteorological message. This plan manifested its utility, but placed too heavy a burden on the Institution. In 1870, a meteorological office was established by the Government under the Signal Office of the War Department This office was finally transferred to the Weather Bureau, created in 1891, under the Department of Agriculture. The early development of the Weather Bureau, was thus a telegraph-engineering development due to Henry's persistent labors in meteorology.

[17] Bibliography 2c Smithsonian Coll , 21 360

CONCLUSIONS

From what has been above excerpted from Henry's writings, it will be seen that this many-minded man, who made so many notable contributions to basic science, also contributed much to applied science.

When, therefore, it is justly claimed for Joseph Henry that he was a scientist-discoverer, writer, organizer, and administrator, it can be confidently added that he was also an inventor and engineer

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Includes list of Prof J Henry's publications, pp 17-177 Also a report to the Board of Regents, pp 7-124, by S F Baird, later appointed secretary to succeed Joseph Henry In the early pages of this report, attention is paid to Henry's work

2 *Memorial of Joseph Henry* Smithsonian Misc Collection, 1881 No 356 Vol 21 of the series Contains memorial addresses

2a *Obituary memoir on Joseph Henry* Prof JOSEPH LOVERING, Vice-Pres of the Am Academy of Arts and Sciences Smithsonian Misc Collection **21**: 427-439

2b *Henry as a discoverer* Memorial address by ALFRED M MAYER Smithsonian Misc. Collection **21**: 475-593

2c *A memoir of Joseph Henry* A sketch of his scientific work by WILLIAM B TAYLOR Read before the Phil Society of Washington, Oct 26, 1878 pp 230-368 Phila 1879

2d *A memoir of Joseph Henry* SIMON NEWCOMB, Washington 1880 Smithsonian Misc Collection **21**: 441-473

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17 *Certain aspects of Henry's experiments on electromagnetic induction* President JOSEPH S AMES, Johns Hopkins University This JOURNAL, 21: 493 Science, Jan 22, 1932 75: 87-92 First Henry Lecture, Oct 24, 1931
18 *Lectures on natural philosophy by Professor Henry* Notes of WM J GIBSON Feb 28, 1844, Princeton

GEOLOGY —*Tentative correlation of American glacial chronology with the marine time scale* [1] C. WYTHE COOKE, U S. Geological Survey.

When the great ice sheets crept down from the north during the Pleistocene epoch and covered Canada and parts of the northern States of the Union, they brought with them boulders and other spoil torn from the land across which they had pushed. At the southern end of each sheet, where the ice melted as rapidly as that behind advanced, great piles of débris accumulated in the form of terminal moraines or was swept onward by gushing rivers Whenever the ice melted faster than it advanced, the ice front retreated northward and the ground beneath it was once more exposed to the weather Soil formed, vegetation grew, and animals that had been driven away by the advance of the ice returned to graze, browse, or hunt

After many years of intensive study of the glacial deposits, geologists have unravelled the tangled thread of Pleistocene history and have woven from it a brilliant tapestry depicting the interesting events of the Ice Age. They recognize a whole series of invasions of the ice each of which is separated from the preceding and succeeding invasions by long intervals of more or less complete deglaciation. Although there is not complete agreement among glacial geologists as to the details of what happened during the Pleistocene, most of them think that there were five principal periods of glaciation and that the last, the Wisconsin glacial stage, was marked by four separate advances of the ice Altogether, therefore, there were at least eight glacial stages or substages and seven interglacial stages or substages

While these battles between the forces of summer and winter were cutting their scars on the land, what was happening to the sea? Every ton of ice that was piled upon the land during the glacial stages came ultimately from the sea and was returned to it when it melted. Thus the level of the sea fell or rose as the continental ice caps waxed and waned. The comparatively short glacial stages were times of low water in the sea. During the much longer interglacial stages the

[1] Published by permission of the Director of the U S Geological Survey Received April 18, 1932

oceans overflowed their basins and flooded the low margins of the continents. The marks made by the sea on the continents during the glacial stages are now submerged, but the abandoned strand lines of the interglacial stages, flanking marine terraces, now stand above sea level. Eight such high strand lines have been detected along the Atlantic coast of the United States and in many other parts of the world.

The problem of correlating the glacial deposits with the marine Pleistocene terraces and strand lines is difficult of direct attack because the glacial deposits are best developed inland, far from the coastal terraces. Field studies in New Jersey and on Long Island, where

TABLE 1.—TENTATIVE AGE OF PLEISTOCENE TERRACES

Approximate altitude of strand line		Name of terrace	Glacial and interglacial stages
Feet	Meters		
270	82	Brandywine	Pre-Nebraskan warm stage Nebraskan glacial stage
215	66	Coharie	Aftonian interglacial stage Kansan glacial stage
170	52	Sunderland	Yarmouth interglacial stage Illinoian glacial stage
100	30	Wicomico	Sangamon interglacial stage Iowan glacial stage
70	21	Penholoway	Peorian interglacial stage 1st Wisconsin glacial substage
42	13	Talbot	1st Wisconsin interglacial substage 2nd Wisconsin glacial substage
25	8	Pamlico	2nd Wisconsin interglacial substage 3rd Wisconsin glacial substage
12	4	Princess Anne	3rd Wisconsin interglacial substage 4th Wisconsin glacial substage

late Wisconsin moraines cut across several terraces, may yield definite evidence as to the relative ages of the later members of the two series, but the earlier glacial deposits are not completely represented there.

An indirect method of arriving at tentative correlations of the two types of deposits is to compare the sequence of glacial stages with the sequence of strand lines and terraces. The latest Pleistocene strand line should correspond to the latest interglacial stage and each successively older strand should fit into its corresponding place in the glacial chronology. An attempt to do this was made in 1930[2] but the

[2] C. Wythe Cooke. *Pleistocene seashores.* This JOURNAL **20**: 389–395. 1930; *Correlation of coastal terraces.* Jour. Geology **38**: 577–589. 1930.

result was defective because the complete sequence of terraces and strand lines was then unknown. In order to make the two time scales fit it was necessary to recognize only two glacial substages within the Wisconsin although it was known that the Wisconsin is susceptible of division into four. A new attempt, shown in Table 1, utilizes the complete series of glacial stages and substages as well as all the Pleistocene strand lines now recognized by students of terraces. The two scales dovetail perfectly. There is no change from the 1930 correlation in the assignment of the older strand lines to a place in the glacial chronology, but additional terraces (the Talbot with a strand line at 42 feet, and the Princess Anne,[3] with a strand line at 12 feet) are inserted into the Wisconsin

It can scarcely be expected that the tentative correlation here proposed will prove to be final or that it will soon receive general acceptance. It is merely offered as an improvement over that of 1930, which was admittedly highly speculative.

[3] In 1931 (this JOURNAL **21**: 513) I expressed doubt as to the validity of the Princess Anne terrace On further investigation the terrace seems to be recognizable

ZOOLOGY.—*A new coati from Nicaragua.*[1] E. A GOLDMAN, Biological Survey.

Among mammals collected in eastern Nicaragua by Dr. Charles W. Richmond, many years ago, is a coati which seems to represent a subspecies that has been overlooked. General comparisons indicate marked contrast with its nearest congeners in color. The new form may be known by the following description:

Nasua narica richmondi subsp nov.

Nicaragua Coati

Type—From Escondido River, 50 miles above Bluefields, Nicaragua No 51331, ♂ adult, U S National Museum (Biological Survey collection), collected by Charles W Richmond, November 19, 1892. Original number 158.

Distribution.—Humid tropical forested region of eastern Nicaragua, and probably adjoining parts of eastern Honduras, passing farther west into *Nasua narica bullata.*

General characters.—A large extremely dark-colored subspecies—darkest of the North American members of the group, with small teeth. Most closely allied to *Nasua narica bullata* of western Costa Rica, but still darker, black or very dark brownish black predominating over most of body, except where relieved by strongly contrasting white markings, cranial characters distinctive. Similar to *N. n. narica* and *N n yucatanica* of Mexico, but much darker colored than either and differing from both in combination of cranial characters.

[1] Received April 13, 1932

Color.—Type: General color of upper parts very dark brownish black, unmodified over top of head and on posterior part of back, rump, and thighs, but finely flecked with light buff across anterior part of back, the flecking involving only extreme tips of hairs, changing gradually to tawny between shoulders, outer sides of forearms overlaid with silvery white, the long white tips of hairs here contrasting strongly with the dark general body tone, under parts in general very dark brownish black, pure along median line of abdomen, dark brown mixed with white on chest, under side of neck and inner sides of forearms, white facial markings as usual in the group, but light lines between eyes narrow and inconspicuous, ears broadly edged with white; feet deep glossy black, tail very dark brownish black with scarcely a trace of annulations discernible

Skull.—Similar to that of *N n bullata*, but more slender, rostrum and interorbital region narrower, teeth, especially the molars, and posterior premolars smaller, audital bullae large and fully inflated as in *bullata* Approaching that of *N n. narica*, but larger, audital bullae relatively larger, more fully inflated, dentition similar, but posterior premolars smaller Compared with that of *N n yucatanica* the skull differs in decidedly larger general size, and relatively larger, more inflated bullae

Measurements —Type Total length, 1,190 mm ; tail vertebrae, 630, hind foot, 109. *Skull* (type) Occipitonasal length, 132 9; condylobasal length, 129 8; zygomatic breadth, 75 2, interorbital breadth, 28 5, crown length of three large posterior cheek teeth (posterior premolar and molars), 21 8, crown width of posterior premolar, 7 1

Remarks —The very dark coloration of *Nasua narica richmondi* is a character shared in common with the regional representatives of several other groups of mammals. In cranial characters *richmondi* is somewhat intermediate between the larger more robust subspecies, *N n bullata*, and the smaller slenderer form, *N n. yucatanica.*

Specimens examined —Two, from Nicaragua as follows. Escondido River (50 miles above Bluefields), 1, (type), Segovia River, 1

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY

482ND MEETING

The 482nd meeting was held in the Cosmos Club, November 25, 1931, President MEINZER presiding

Program MARIUS R CAMPBELL· *The alluvial fan of Potomac River* —The great deposit of gravel on the peninsula which projects southward between the Potomac and Patuxent rivers and to which the name Brandywine was given by William B Clark, instead of being a marine deposit as has heretofore been supposed, is a great alluvial fan built of gravel and sand brought down by the Potomac River The distinctive material is fossiliferous chert which is not available for transportation by any other river in this region This chert was traced from Anacostia to Point Lookout, Md , and thence across the Potomac River to Warsaw and Rappahannock, Va and as far south as Urbana on the Rappahannock River The area covered is at least 70 miles long and 40 miles wide in the widest part It was deposited when the Rappahannock River had a course different from that which it has at present and when sea level was approximately 100 feet higher than it is today. (*Author's abstract*)

Discussed by MISS BASCOM and MR STOSE.

G. F Loughlin and A. H. Koschmann *Dissected pediments in the Magdalena district, New Mexico* —The Magdalena district, New Mexico, is in the southeast part of the Basin and Range Province It includes the north end of the Magdalena Range and Granite Mountain, which consist of tilted and faulted sedimentary rocks of Carboniferous age and volcanic rocks of Tertiary age on a pre-Cambrian basement The lava flows originally extended across the present valleys and over the Magdalena Range, but the earliest stages of erosion swept the volcanic cover from the main range, completely in the northern part, but only partly south of the town of Kelly.

The Magdalena Range and Granite Mountain are bounded on the east and on the west by extensive plains, which have been found to be pediments covered by a veneer of alluvium The foot-hills and lower slopes of the range include many flat and gently westward sloping spurs and benches which are interpreted to be remnants of older, dissected pediments Some of them are still capped by patches of alluvium or remnants of old landslides. The more abundant and better defined benches are grouped at six different levels Others at still higher levels may also represent old pediments, but are too few to be convincing

The uplift of the range was accompanied by extensive faulting, and the present valleys are in areas of the down-warped and down-faulted volcanic formations that were most readily eroded, but no appreciable amount of faulting has taken place recently enough to account for any of the better defined benches

The dissection of the pediments is attributed to the general lowering of the Magdalena Plain, due to the tapping of its drainage lines by San Lorenzo and La Jenze Creeks, which are tributary to the Rio Grande The development of the different stages of erosion, marked by the rock benches and the high and low alluvium, is believed to be related to the varying rates at which these streams cut their ways downward through the volcanic flows and tuffs that lie east and northeast of the Magdalena Range, but, owing to insufficient information regarding the history of the Rio Grande Valley, definite correlation must await further study (*Authors' abstract*)

Discussed by Messrs Atwood, Parker, Hunt, Hewett, and Loughlin

E T Allen *Geysers* —Geysers are by no means as well known as is generally supposed Such important characteristics as (1) an intermittent rise and fall of the water level in many geysers, (2) an intermittent discharge in many, (3) common association with a surface layer of superheated water, and (4) the frequent occurrence of a maximum temperature before the bottom of the geyser well is reached remain either undescribed or little known

The original theory of geyser action proposed by Bunsen and Descloizeaux left out of account an influx of colder water after every eruption which alone can explain periodicity (Lang) Bunsen and Descloizeaux's principal contention that temperatures at every depth in the geyser well increase steadily with time between eruptions is not supported by their data (Thorkelsson) It is difficult if not impossible to reconcile the facts with the Bunsen and Descloizeaux theory, only by the assumption of a side chamber connected with the geyser well by a narrow channel, a chamber in which geyser action originates, can this be done

Data from the Yellowstone Park were presented in support of Lang's hypothesis, that a geyser may become extinct through steam leakage in the side chamber On the assumption that the heat supply of geysers is transported by jets of magmatic steam through seams in the rock, the life of a geyser might be ended by a diversion of a local supply to other quarters by the gouging out of new passages by the solvent action of hot water

The erratic variations in geyser behavior are certainly not due to seasonal changes, but so far they remain entirely unexplained. (*Author's abstract.*)

Discussed by Messrs MATTHES, JOHNSTON, RUBEY, ALDEN, and FENNER

483RD MEETING

The 483rd meeting was held at the Cosmos Club, December 9, 1931, Vice-President F. L HESS presiding

Program O. E MEINZER delivered his presidential address *History and development of ground water hydrology*

39TH ANNUAL MEETING

The 39th annual meeting was held at the Cosmos Club after the adjournment of the 483rd regular meeting, President O E MEINZER presiding The annual report of the secretaries was read The treasurer presented his annual report showing an excess of assets over liabilities of $1,357 02 on December 6, 1931. The auditing committee reported that the books of the treasurer were correct

The results of balloting for officers for the ensuing year were as follows *President* F E MATTHES; *Vice Presidents* F L HESS and H. G. FERGUSON, *Secretaries* J F. SCHAIRER and W H BRADLEY, *Treasurer* C WYTHE COOKE, *Members-at-Large of the Council* FRANK REEVES, T B NOLAN, E P HENDERSON, F G WELLS, and C E RESSER, *Nominee as Vice President of the Washington Academy of Sciences representing the Geological Society* O E MEINZER

C H DANE, J F SCHAIRER, *Secretaries*

484TH MEETING

The 484th meeting was held at the Cosmos Club, January 27, 1932, President MATTHES presiding

Program CHAS B HUNT *The junction of three orogenic types in New Mexico*—Three orogenic types are represented in an elongate belt of country lying midway between Albuquerque and Mt Taylor, New Mexico The exposed rocks are of Upper Cretaceous age and consist of the Mancos and Mesaverde formations which intertongue The main body of the Mancos underlies the Mesaverde and is underlain by the Dakota (?) sandstone

Three physiographic provinces, the Colorado Plateau, the Southern Rocky Mountains, and the Basin and Range, each with a distinctive type of structural deformation, come together in this area

The southeast border of the Colorado Plateau consists of little faulted and gently folded strata The Nacimiento Mountains of the Southern Rocky mountains are an anticlinal uplift, asymmetric in cross section with the steep flank to the west A reverse fault has been reported along the west flank The uplifting probably ended in the Miocene The Rio Grande valley belongs to the Basin and Range province and consists of blocks separated by faults having parallel trends So far as known all the faults are normal The major faults attain a maximum displacement of 3500 feet The few exposures of striae found on the fault faces indicate vertical rather than horizontal movements The major faults produce a stepdown to the west, and most of the fracture surfaces dip west as low as 45°. The strata dip east generally between 10° and 20° Locally the dip increases to nearly 40°. The structural level of the Colorado Plateau is considerably higher than the Basin and Range which has been dropped down by faulting and monoclinal folding

The deformation of the Basin and Range province in this area ended in the Miocene and therefore is probably contemporaneous with the uplifting of the Nacimiento Mountains.

The dominant regional fold of the Rio Grande valley at Albuquerque in the Basin and Range province is an anticline which is the southward continuation of the Nacimiento anticline It was a growing uplift during the middle Tertiary as was the uplift of the Nacimiento Mountains. The anticline in the valley collapsed by means of block faulting during the process of uplifting. Both the faulting and the uplifting ceased in the Miocene. (*Author's abstract*)

Discussed by Messrs KING, HEWETT, PARKER, L A SMITH, RESSER, and MATTHES

W T. SCHALLER *The crystal cavities of the New Jersey zeolite region.*—The regular crystal cavities associated with zeolitic rock in the trap rock quarries in and near Paterson are evidence of the former existence of crystals of minerals, now dissolved away.

The geological features indicate that the trap rock lava flowed into a Triassic lake rich in glauberite, a sulphate of sodium and calcium These constituents, dissolved by the heated waters and mixed with the molten rock, crystallized out in the lava as anhydrite whose later solution formed rectangular cavities, and as glauberite, which formed rhombic cavities Some of the lamellar cavities may be due to lamellar calcite crystals, which crystal habit, tabular parallel to the base, is the high temperature crystal form of calcite

Anhydrite has been found in the trap rock in rectangular crystals, partly changed to gypsum and to thaumasite and partial and complete removal of these alteration products has formed rectangular cavities Infiltration pseudomorphs of quartz in some of the rhombic cavities have yielded cores bounded by crystal faces whose angular values are those of glauberite

Babingtonite, which has been suggested as the original mineral of the cavities, does not agree in its crystallography and cleavages with the shapes of the cavities Moreover, its period of formation is much later than the minerals forming the cavities (*Author's abstract*)

PARKER D TRASK *Relation of calcium carbonate content of sediments to salinity of the surface water*—Salinity appears to be an important factor in the deposition of calcium carbonate in marine sediments A statistical study of 3,000 samples from all parts of the world shows that temperature and depth of water being constant, the carbonate content of the deposits varies with the salinity of the surface water Sediments accumulating in regions in which the surface salinity is less than 34 parts per thousand, as a rule contain little carbonate and those forming in areas in which the salinity is greater than 35 parts per thousand generally contain considerable carbonate. The critical salinity is about 35 parts per thousand This relation holds for both near-shore and pelagic sediments, but pelagic deposits for given salinities contain more carbonate than do near-shore sediments

Temperature and depth of water appear also to influence the deposition of carbonate, but the effect of surface temperature and of depths less than 1500 fathoms seems to be less than that of salinity In pelagic areas, depths greater than 1500 fathoms probably affect the carbonate content slightly more than does salinity

Carbonate deposition almost certainly is influenced to a considerable extent by the activity of living organisms, but this phase of the problem was not investigated particularly However, if organisms are the dominant factor

in carbonate deposition, it seems evident from the data compiled that their activity to some, and perhaps to a considerable, extent depends on salinity, especially on variations between 34 5 and 35.5 parts per thousand.

The chief geologic interpretations of the data presented in this paper are (1) that if a recent marine sediment contains less than 2 per cent $CaCO_3$ the chances favor its having been deposited in brackish water or in a region of subnormal salinity; and (2) that if a sediment has more than 50 per cent carbonate, that is, if it is a limestone-forming deposit, it probably accumulated in water having a salinity greater than normal. These generalizations indicate probabilities in the sense of mathematical odds. That is, if 100 random samples were chosen, considerably more than 50 of them would accord with the generalization expressed. However, not all of the hundred samples would agree with it, because salinity is only one of several factors affecting the accumulation of carbonate, and in any individual environment it is possible for other factors to mask the influence of salinity

If carbonate deposition in the geologic past was governed by the same conditions as at present, climate in some places may have played an important part in the deposition of carbonate For example, in some epicontinental seas whether or not the deposits would be calcareous might depend to a considerable extent upon whether the loss of water by evaporation was greater or less than the addition of water by rainfall or from land That is, alternations between limestone and shale or between calcareous and non-calcareous shale in some places may have been caused more by changes in climate than by shifts of strandline This hypothesis is not presented as indicating the general rule, but as only one of the factors to be considered in the interpretation of the conditions of deposition of sediments of past geologic age (*Author's abstract*)

Discussed by Messrs. R C WELLS, VISCHER, SCHAIRER, PARKER, BRAMLETTE, WOODRING, RUBEY

485TH MEETING

The 485th meeting was held at the Cosmos Club, February 10, 1932, President MATTHES presiding

Program: W D JOHNSTON, JR. *Structure of the Grass Valley batholith, California*—A small granodiorite batholith—5 miles long and ½ to 2 miles wide—on the western slope of the Sierra Nevada Mountains offers unusual opportunity for structural study by means of the extensive mine workings which penetrate the intrusion to a vertical depth of 3700 feet below the surface and follow vein fractures underground for over two miles along the strike Lindgren, Howe, and Knaebel have described the Grass Valley gold quartz deposits and considered the structural relations as a whole

With the exception of the Idaho-Maryland group which are localized by the serpentine-diabase contact in the host rocks, the veins are roughly parallel with the margins of the batholith and the principal veins dip into the granodiorite at an average angle of 35 degrees A second set of veins, less in number and in gold values, form a conjugated system with the former. All measurable displacements on the veins are thrusts Together the two series of veins define the planes of maximum shear resulting from compressive stresses operating along a horizontal axis normal to the long axis of the batholith.

A series of almost vertical fractures, locally called "crossings" of approximately the same age as the vein fractures strike in the northeast quadrant, transverse to the long axis of the batholith Many of these fractures are occupied by acidic and basic dikes

In the mechanical conception of igneous intrusives developed by Cloos the veins occupy marginal thrusts and the conjugated back-dipping shear plane and the "crossings" are tension or *q* cracks

If the original mechanical system be viewed by means of a strain ellipsoid the axis of maximum pressure lies in a horizontal plane normal to the long axis of the batholith, the intermediate pressure axis is horizontal and parallel with the long axis of the batholith and the axis of minimum pressure is vertical.

Prior to quartz mineralization the vertical tension cracks were closed and subsequent relief from compressive stresses was upward, resulting in the opening of the vein fractures for the deposition of quartz (*Author's abstract*)

Discussed by Messrs FERGUSON, RAY, HEWETT, and L H SMITH

W H BRADLEY *Erosion surfaces on the north flank of the Uinta Mountains* —Long remnants of the Bishop erosion surface capped by the Bishop conglomerate extend northward from the north flank of the Uinta Range This surface which rises from an elevation of about 7,300 feet out in the basin to nearly 13,000 feet near the crest of the range is interpreted as a pediment formed under an arid or semi-arid climate by the lateral corrasion of a group of graded streams controlled by a common base level The Bishop conglomerate is interpreted as a deposit formed in response to a shift in climate toward greater aridity than prevailed while the underlying surface was being cut

About 400 to 500 feet below the remnants of the Bishop pediment are remnants of another pediment formed in essentially the same manner This is the Browns Park pediment or surface, remnants of which are covered by the Browns Park formation at the east end of the Uinta Range The Browns Park and Bishop surfaces were formerly thought to be equivalent, but the Bishop surface has now been traced eastward and correlated with the nearly level top of Cold Spring Mountain which in turn lies about 500 feet above an undisturbed remnant of the Browns Park surface Thus the Bishop conglomerate is older than the Browns Park formation whose age is now regarded as late Miocene or early Pliocene

After the deposition of the Browns Park formation the east end of the Uinta Range collapsed Into this graben the Green River was diverted, probably by a combination of piracy and warping It then flowed on the uppermost beds of the Browns Park formation and apparently was soon thereafter captured by the headward erosion of a tributary to Pot Creek which drains Summit Valley This capture diverted it so as to flow across the main Uinta Range along the site of Lodore Canyon Heretofore the course of the Green River through Lodore Canyon has been regarded as superposed from the Browns Park formation. (*Author's abstract*)

Discussed by Messrs MATTHES, SEARS, and ALDEN.

HUGH S. SPENCE (Mines Branch, Department of Mines of Canada)· *Pitchblende deposits at Great Bear Lake, Canada*

Discussed by Mr. HESS.

486TH MEETING

The 486th meeting was held at the Cosmos Club, February 24, 1932, President F. E MATTHES presiding

Informal communications Mr. D. F HEWETT read a letter from Chester

Washburne who suggested the generalization that normal fault surfaces are concave toward the downthrown side (the active side) in regions of igneous activity and concave toward the upthrown side (the active side) in regions remote from igneous activity

Discussed by Messrs A. KEITH, J C RAY, and P J SHENON

Program: N H DARTON *Some Algonkian strata in Arizona and adjoining regions* —The purpose of this paper is to show that most of the strata of the Apache group of central Arizona are unconformably overlain by sediments containing fossils of Middle and Upper Cambrian age and are very closely similar to the Unkar and Chuar groups of the Grand Canyon The stratigraphic succession in the two regions is, however, somewhat dissimilar The Dripping Spring quartzite and associated shale and conglomerates and the overlying Mescal limestone which constitute a large part of the Apache group have all the striking characteristics of the Shinumo quartzite, Bass limestone, and red Hakatai shales, of the Unkar group as exposed in the Grand Canyon The peculiar intrusive diabase sills conspicuous in both areas are remarkably alike They are all pre-Cambrian and have caused the development of crysotile bodies in certain impure members of both the Mescal and Bass limestones which they invade These two formations contain a large amount of algal material, which according to recent observations by Resser and Stoyanow also occurs in abundance in some members of the Chuar group The Mescal limestone, which is an important ore carrier in the Old Dominion Copper Mine at Globe, is overlain in many places by a thin flow of vesicular basalt similar to those in the Chuar group This is overlain unconformably by sandstone with local conglomerate containing fragments of the old lava This overlying sandstone, which is the Troy or top formation of the Apache group, has yielded Cambrian fossils which will soon be described by Dr. Stoyanow of the University of Arizona He has found them not only in the upper member in which I discovered the Abrigo fauna some years ago, but also in the lower beds where in places they are of Middle Cambrian age The relations of these sandstones vary in different parts of the region but to the southeast they have been traced into the Bolsa quarztite which underlies the Martin (Devonian) limestone It is now proposed to limit the application of the term Apache group to the Mescal and underlying strata

The Millican formation in the region about Van Horn, Texas, with its diabase intrusions, algal limestones, red shale, and quartzites is somewhat similar to the Apache group The Lanoria quartzite in Franklin Mountains near El Paso with its diabase intrusions also presents features of resemblance and similarity of history to the exposures in Arizona The Mazatzal and some other quartzites in Arizona and New Mexico are probably earlier (*Author's abstract*)

Discussed by Messrs RESSER, HEWETT, and KING

ERNST CLOOS. *Is the Sierra Nevada batholith a batholith?*—A structural survey of the Sierra Nevada batholith, between Mono Lake and the Mother Lode, was carried out in 1930–1931 The methods applied were those described by Hans Cloos, Robert Balk and others

The Sierra Nevada intrusive body was found to be a composite mass, of which the components show their own structural individuality. The first intrusions took place along tectonic or stratigraphic boundaries, the following ones preferred the boundary between previous intrusions and the wall rock. The contacts usually dip steeply, generally *under* the batholith, but near Mariposa, the inward dip is only 30 to 40 degrees A very intense flow structure follows the contacts, closing to an arch or dome in the center The

dome shape is believed to be caused by retardation of the semiliquid magma during its rise along the contacts Joint fans were formed at a later stage, indicating the continuance of the upward movement during consolidation of the magma Marginal thrusts along the contacts effected an upward elongation of the margins Thrusts, following the Mother Lode Zone were formed in a similar way and indicate a close relationship between the Mother Lode structure and the batholithic intrusion

No signs of differentiation in the present magma chamber were found. All partial intrusions show clear contacts and a pure composition from one contact to the other Differentiation of these magmas must have taken place in greater depths No assimilation contacts, signs of convection currents, or traces of sinking blocks were observed

To judge from the available data, the Sierra Nevada batholith does not seem to be a true batholith, in the sense of Suess or Daly A succession of intrusions, beginning in the area of the Mother Lode Zone, opened and gradually widened a gap The first intrusions preferred stratigraphic or tectonic boundaries Those following took advantage of the boundaries between previous intrusions and the wall rock

The regions of uniform internal structure grew gradually with increasing rigidity The *schlieren* dome is overlapped by an arch of flow lines The latter is overlapped by joint fans As the rigidity increased, regional joints became more and more important, until finally the whole area between the eastern fault and the Mother Lode reacted as one block (*Author's abstract*)

Discussed by Messrs MATTHES, FERGUSON, and CLOOS

J F SCHAIRER and W H BRADLEY, *Secretaries*

SCIENTIFIC NOTES AND NEWS

At the dinner of the National Academy of Sciences on April 26, the Mary Clark Thompson Medal was presented to Dr DAVID WHITE, U S Geological Survey, the presentation address being made by Professor WILLIAM B SCOTT, of Princeton University

The John Price Wetherill Medal has been awarded by the Franklin Institute to Dr FRANK WENNER of the Bureau of Standards "in consideration of his ingenious design of a recording teleseismograph of superior performance"

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PERSONNEL ADMINISTRATION.—*Some aspects of the classification of professional and scientific positions.*[1] WM. H. MCREYNOLDS, Personnel Classification Board. (Communicated by HUGH L. DRYDEN.)

In 1923 Congress passed an act to provide for the classification of civilian positions in the Government service in the District of Columbia on the basis of their duties and responsibilities and for the allocation of such positions to the appropriate levels of the compensation schedules prescribed in the act. The law defines the general standards by which positions are to be evaluated An administrative agency, the Personnel Classification Board, is charged with measuring individual positions in terms of these standards and allocating them to their proper places in the classification plan.

The Classification Act groups related types of work, across organizational lines, in broad divisions known as "services." Positions now under the Classification Act of 1923 are grouped in five services· The Professional and Scientific Service, the Subprofessional Service; the Clerical, Administrative, and Fiscal Service, the Custodial Service; and the Clerical-Mechanical Service. The Professional and Scientific Service contains somewhat over 5,000 departmental positions allocated in nine grades or zones of difficulty and responsibility, with salaries ranging from $2000 to $9000 and above.

The variety of professional, scientific, and technical positions in the Government service is surprising, invariably so to one not familiar with the service as a whole. These positions embrace practically every branch of subject matter covered by university curricula and, moreover, many branches peculiar to the public service. In addition

[1] Received April 26, 1932. This paper, which was originally presented before the scientific group of the Department of Agriculture, is believed to be of interest to members of the Academy

to this wide scope of subject matter, the professional and scientific positions are as a group characterized by a considerable variety of functional applications of the same subject matter. For example, in one of the agricultural sciences we may note functions of research, regulation, or demonstration and extension; and in engineering we may observe project-investigation, design, construction, inspection, testing, research, and operation, as well as administration and regulation.

In view of the variety and scope of professional and technical positions, it is clear that without certain principles of classification to guide us in evaluating and interpreting the facts about individual positions as they are presented to us from day to day, we could not even closely approach the goal of allocating these positions uniformly in the various grades. The basic principle of the Classification Act seems very simple. It is that all positions are to be classified or allocated on the basis of the importance and difficulty of their duties and responsibilities. Yet there is a corollary to this that is occasionally misunderstood, even today. That corollary has to do with the relationship of the qualifications of the present incumbent of a position to the allocation of that position.

Confusion on this score always arises when a grade allocation is thought of, not as an appraisal of the position occupied by an employee, but as an appraisal of the employee himself. It is easy to see why some professional and scientific workers might accept this as the orthodox idea, because of the emphasis placed by scientific individuals and societies upon the qualifications, standing, and accomplishment of the individual, the actual position occupied being regarded as merely one item of evidence pointing toward the achievement of the employee. Following the same line of thought, it would be natural, then, to think that the purpose of an allocation is to recognize the employee's achievements over a long period of years and his present standing in his profession, without analyzing closely the tasks or the responsibilities of the employee in the Government service at the time the allocation is being considered. The emphasis, however, should be in the other direction. The allocation is a recognition of the current tasks and responsibilities of the employee, and if it has so happened that these tasks and responsibilities have been assigned to him or have gradually developed because of his professional standing and ability, then in a certain sense it recognizes him also; but the allocation is an appraisal of the position, not of the employee. We sometimes speak in everyday parlance of a P-5[2] chemist, or a P-6 engineer, but what we mean is that here is a

[2] This is a symbol representing grade 5 of the Professional and Scientific Service Grade 1 is the lowest grade of this service and grade 9 the highest

chemist who is occupying a P-5 position or an engineer who has a position of P-6 level. As a matter of fact, it is readily conceivable that a chemist who has P-5 qualifications may be assigned to a P-3 position, because, for instance, no other assignment is available. He would then be a P-5 chemist on a P-3 position and would consequently receive a salary within the P-3 range. Considering the matter broadly, two things have to coincide in order for an employee to receive a salary within the range of a particular grade. First, (this is the item which is occasionally lost sight of) he must be assigned to work of that grade; and second, he must possess at least the minimum qualifications for that grade. Obviously a college graduate assigned to simple clerical work would not receive a P-1 salary. This illustrates the familiar statement that the Classification Act provides for a classification of positions and not for a classification of the employees occupying them.

In order to appreciate the significance of this statement, it is necessary to realize that in personnel administration—not only in the Government service, but generally—a sharp distinction is made between a position and an employee. A position is composed of one or more tasks or assignments that are to be performed by a single individual. It comes into existence through the action, authorization, or permission of the head of the department or establishment in which it is located. It may be occupied or vacant. It is characterized by its duties and responsibilities, and so long as these criteria remain the same, the position remains the same regardless of the fact that it may be occupied by different employees at different times. A position often exists before it is occupied by any one and it does not necessarily cease to exist when its incumbent is separated from it. When its duties and responsibilities materially change regardless of the cause of that change, it is a different position, calling perhaps for a different classification or allocation. Such a change may take place because of a division or merger of two or more positions, or because of a gradual development of the position caused by the growth of the employee himself. In this last situation the change generally takes place so imperceptibly that it is necessary to emphasize that the former position has been transformed into another one of different characteristics, the former one usually, but not necessarily, being regarded as having disappeared.

One of the considerations aiding in the classification of a position is the qualifications required of any incumbent for the performance of the duties and the discharge of the responsibilities involved. Qualification requirements are inferences drawn abstractly from the informa-

tion as to the duties and responsibilities, and to state them is one method of indicating how difficult or complex these duties and responsibilities are. Simple duties require little training and experience. Difficult duties require longer training and experience and demonstration of definite attainments. Statements of minimum qualifications to be required of *any* future incumbent of a given class of positions are particularly enlightening in considering the allocation of newly-created positions or vacancies. Their value lies in the fact that they have a generic significance, not a significance dependent solely on the qualifications of one person.

The difficulty is that many persons confuse the concept of qualifications required for a position—whoever the incumbent may be—with the actual qualifications possessed by some particular incumbent. Sometimes the incumbent possesses less than the required qualifications. That may be a mistake in assignment, but the allocation of the position should not be lowered so long as it is a fact that he is doing the work upon which the allocation was granted. Sometimes he possesses more than the required qualifications; but the allocation of the position should not be raised unless and until the duties and responsibilities of the position have substantially increased—a phenomenon which may be due to these higher qualifications or to any one of a number of other causes.

The fact is that duties actually performed and responsibilities actually exercised are the characteristics that serve as the basis of classication; *qualifications that incumbents may happen to possess or lack* do not determine the classification of their positions, although such possession or lack may be the reason why the duties and responsibilities are such as they are.

It is according to these principles that a position and its incumbent are regarded as separate and distinct for classification purposes, although, at the same time, it is recognized that one may have a strong influence on the other. In that part of the administrative organization of the Government which deals with central personnel management, there is a separation of function and authority along these same lines. It is the department and the Civil Service Commission that have the authority to appraise the employee and to designate him as eligible for a position of a particular grade. In a certain sense such action would be a classification of the employee and not of the position. With that decision the Board has nothing to do. It is its authority to appraise the position. Its jurisdiction is to see whether the position in question is composed of tasks or assignments of the requisite im-

portance, difficulty, and responsibility to characterize it as properly belonging in the grade recommended by the department; if so, the Board approves that grade; if not, the Board determines the grade which in its judgment is the correct one.

As was mentioned a moment ago, although the Personnel Classification Board is required to appraise positions and not the qualifications of their incumbents, it is easily apparent that the qualifications an employee may possess or lack can, and many times do, influence the character of the duties and responsibilities he is authorized or permitted to assume. In no type of work is this more frequent than in the field of scientific research. In administrative positions the responsibilities and the duties usually are somewhat more closely defined. There is not, as a rule, so large an opportunity for the growth of the position. In fact, some administrative positions are so circumscribed by law or administrative regulation as to render their basic characteristics only slightly responsive to the personal accomplishments of the incumbent. In the higher-grade research positions, however, it is almost invariably true that as a scientist develops, his position is allowed to develop with him, towards the final situation where the limits of its duties and responsibilities coincide with the limits of his own capabilities.

This leads us to another phase of classification that holds considerable interest for the professional and scientific group. That is the relationship between the allocation of administrative or operating positions and the allocation of research positions.

In view of the direct benefits of research to progress in the industrial and agricultural arts, it is, of course, true that national governments, in this country and elsewhere, recognize the advantages of research as a public function and encourage and foster it through appropriations from the public treasury. So we find, in the structure of our own Government, positions having the conduct of research as their main objective. These range from the junior positions with responsibility only for certain routine tests or determinations to the positions having as their main characteristic the rendering of service of unquestioned authoritativeness in a given branch of science and the maintenance of the Government's prestige in that branch.

As between pure and applied science and as among the various branches of science, no distinctions were manifested in the definition of the grades in the Classification Act. There was no indication that Congress intended to discriminate, for example, between work having as its immediate result the direct alleviation of human disease and

suffering, and work the immediate result of which might be, for the time being, only an extension of the boundaries of knowledge. As a matter of fact it would have been unwise, even if it had been practical, for Congress to attempt such a distinction, for the history of science is replete with instances where research for knowledge for its own sake has paved the way for outstanding benefits to the people.

As between research and administration, however, the original Classification Act of 1923 drew specific parallels in the fourth and fifth grades of the Professional and Scientific Service, which consisted of but seven grades at that time. These parallels indicated clearly that up to and including the P-5 grade, which then carried a salary range of $5200 to $6000, individual scientific research was intended to go hand in hand with administration of professional and scientific organizations. After that, the Classification Act indicated, administration was to proceed alone except for the company of exceptional consultation service to the head of a department. Accordingly, during the first few years of classification administration, P-5 was generally regarded as the ceiling for individual research. The Board made a few, but relatively very few, allocations of individual research positions to grades higher than the old P-5.

Under the Welch Act, in 1928, an extra grade was added to the professional levels within the Board's allocating authority, and under the operation of that Act there was to a certain extent a reappraisal of positions from P-4 onward, with an upward shifting of values. These changes in the upper levels had as one of their specific effects the liberalizing of standards of allocation for research positions. Since that time, P-7, carrying a salary range of $6500 to $7500, has been generally regarded as available for the allocation of research positions that are sufficiently unique and outstanding from a national or international standpoint to warrant special recognition. This, it may be added, is the foundation for the language used by the Board in defining grade P-7 in the classification bill recommended last year to Congress as a result of the field survey. The terms of the definition of P-7 in this bill specifically place on a parity the three functions of research, practice, and administration in professional, scientific or technical work.

It is, of course, already a familiar fact that in certain organization units within a bureau, it is not unusual—in fact, in some places, rather common—to have research positions in a division allocated in the same grade as the head of the division. This comes about in those instances where the individual research work concerned is of such a nature that supervision and review in the customary sense do not exist and that

the research worker is, as to the technical aspects of his work, virtually independent of the organization structure.

Generally speaking, it is the consensus of opinion in the professional and scientific group that the road of advancement open to the independent worker—the specialist in pure research—should be as long as that which is provided for the worker in applied science or for the official charged with the responsibility for administrative or operating activities. Although there may be differences of judgment as to what in individual research work constitutes a parity with a certain set of administrative responsibilities, and therefore differences of judgment as to how far the idea should be applied, no one can quarrel very much with the spirit of the principle itself.

The Classification Act and its amendments have recognized this principle almost in full measure, even though legislation has not yet been amended to the point of recognizing that individual research workers in any one of the more outstanding bureaus of the Government may be allocated to the same grade as the head of that bureau. It may thus be said that except as to the highest grade to which the Board is authorized to allocate positions, i.e., P-8, the assumption of administrative responsibility is not a prerequisite for any grade. I think it will be agreed that this relationship in the Government Service between the allocation of individual research positions and the allocation of administrative positions is certainly as favorable to the individual research worker as is the corresponding relation in the large corporations of private industry between the salaries of its scientists and those of its highest executives.

PALEOBOTANY.—*A new Palm from the upper Eocene of Ecuador.*[1] EDWARD W. BERRY, Johns Hopkins University.

The specimen which it is the purpose of the present note to describe was sent to me by Dr. George Sheppard of Guayaquil, Ecuador, and was collected from the upper Eocene of the Ancon district, Santa Elena peninsula, Ecuador. It is splendidly preserved as a calcification, and is undoubtedly a new species of palm fruit, and appears to belong in the genus *Astrocaryum* Meyer. It may be described as follows:

Astrocaryum sheppardi n sp Berry

Fig 1

Nut fairly large for this genus, elongated, slightly asymmetric, pointed at both ends—less sharply so proximad Length 7 5 centimeters. Maximum

[1] Received April 12, 1932.

diameter 3.93 centimeters. Minimum diameter 3.65 centimeters. This slight departure from a circular cross section may be natural or it may be due to a slight amount of deformation during fossilization. Germinating pores three in number, round, about 6 25 millimeters in diameter, situated unusually high above the base—the distance ranging from 3 1 to 3.4 centimeters, slightly higher on the more inflated side of the fruit. The contours are rather more straight below the pores and more inflated and rounded above them The surface is corrugated by irregular disconnected (interrupted) longitudinal ribbing, which is more pronounced proximad.

The identification of palm fruits, either fossil or recent is about as baffling as is the identification of palm wood, not because the fruits are not character-

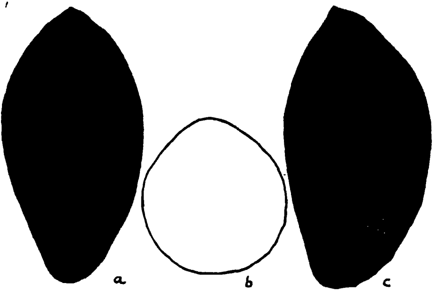

Figure 1 —(*a*) *Astrocaryum sheppardi* from the inflated side —(*b*) Equatorial profile —(*c*) View of side showing two of the germinating pores.

istic, but because specimens of the fruits of recent species are not available in collections nor are they particularly well described by systematic botanists even when known and often they remain unknown Ordinarily paleobotanists evade this difficulty by referring fossil palm fruits to the purely form genus *Palmocarpon*, proposed by Lesquereux in 1878, and now containing upwards of thirty nominal species from different parts of the world. About half of these are from the Eocene of the United States. Others come from Panama, the Antilles, Ecuador, and Peru. They obviously have slight systematic value unless they show definite resemblances to existing genera.

The genus *Astrocaryum*, to which the present species from Ecuador is referred, includes stemless to tall feather palms and contains about thirty existing species These are exclusively American and range from southern Mexico to eastern Peru, reaching their maximum development in the rain

forests of the Amazon basin, although they are also found in the Brazilian Campos. They are not especially coastal types but their fruits are common in the beach drift of both coasts of tropical America, occurring on the beaches of the Pacific coast as far south as Punta Parinas, and here derived in all probability from the Guayas estuary by the action of small inshore counter currents, although it is conceivable that they might occasionally be brought down to the sea from the head waters of the Tumbes or Chira Rivers However, their occurrence along the north Peruvian desert coast associated with unfilled and hence floatable nuts of the Ivory palm would indicate that the former origin was the more likely.

No other fossil species of *Astrocaryum* are known to me A few years ago I described specimens of fruits from the Oligocene of Peru which I referred to that genus,[2] but subsequent collections proved them to belong to the related genus *Attalea* H B. K ,[3] which has about as many existing species and a somewhat similar geographical distribution The fruits of the latter, however lack germinating pores and hence can be readily discriminated from the fruits of *Astrocaryum* when the material is well preserved.

The geological section on the Santa Elena peninsula of western Ecuador is much like that so thoroughly described by Olsson and Iddings in the northwestern coastal region of Peru, and the older Tertiary of the two regions has already yielded a number of identical fossil fruits. This number is likely to be much increased by more detailed collecting in the Ecuadorian region.

[2] Berry, E W , U S Nat Museum Proc 70: Art 3 1926

[3] Berry, E W , Pan Amer Geologist, 51· 242, figs 4–10 1929

ENTOMOLOGY.—*Four new North American species of* Bassus Fabricius *(Hymenoptera, Braconidae), with notes on the genotype.*[1] C. F. W. MUESEBECK, Bureau of Entomology. (Communicated by HAROLD MORRISON.)

In my treatment of the Nearctic Braconinae[2] I briefly summarized the situation concerning the status of the names *Bassus* Fabr. and *Microdus* Nees. The two being isogenotypic and *Bassus* the older name, *Microdus* must be suppressed. The continued European usage of *Microdus* for this group in the Braconidae and of *Bassus* for an ichneumonid genus evidently is due to a disregard of first genotype fixation, and to the acceptance of Westwood's designation (1840)[3] of *Bassus laetatorius* Fabr. as type of *Bassus*, no notice being taken of the designation of *Ichneumon calculator* Fabr. by Curtis[4] in 1825.

[1] Received April 26, 1932.

[2] Proc U. S Nat Mus 69: Art 16, 1927, 73 pp.

[3] Intr Mod Class Ins 2: 59 Gen Syn 1840

[4] Brit Ent. 2: 73. 1825

BASSUS CALCULATOR Fabricius

Ichneumon calculator Fabricius, Suppl. Entom. System, 1798, p. 225.
Bassus calculator Fabricius, Syst. Piez, 1804, p 98.

Since this species was only very briefly characterized by Fabricius, and since subsequent descriptions by other authors apparently have been based merely on material identified as *calculator* and not on the type, which is in the Natural History Museum at Kiel, Germany, the following notes taken from the type specimen are included here·

A female specimen labeled "21 calculator" Agrees with the characterization of *Bassus* in my paper on the Braconinae to which reference has already been made

Length, about 6 mm. Face not rostriform, broad, smooth, antennae missing; temples narrow, receding; frons immargined; ocelli small, mesoscutum polished; notauli sharply impressed, scutellar furrow rather broad, with several foveae within; scutellum smooth; propodeum convex, closely rugulose; mesopleural furrow curved, foveolate, metapleura mostly smooth, areolet (second cubital cell) triangular, sessile, nervulus very slightly postfurcal, mediella a little shorter than lower abscissa of basella; subdiscoidella not distinct; abdomen scarcely as long as head and thorax combined, first tergite broadening gradually behind, longer than broad, shallowly but distinctly striate, without prominent longitudinal keels, a little faint longitudinal sculpture at base of second; remainder of dorsum of abdomen smooth and shining; ovipositor sheaths very nearly as long as body Head black; thorax black, with pronotum, mesoscutum, scutellum, and mesopleura anteriorly, red; abdomen black, anterior and middle legs yellowish, their coxae piceous; posterior legs blackish, base of tibia yellow, wings weakly infumated, with a hyaline area across discocubital cell and extending into second discoidal

Bassus petiolatus, new species

Closely resembling *californicus* Mues, but distinguishable by the more rostriform face, weakly sculptured propodeum, mostly reddish or reddish yellow abdomen, and more slender legs

Female—Length, 5 mm Head strongly produced below; malar space nearly as long as eye and nearly vertical; clypeus long, less than one and one-half times as broad as long, a low ridge on frons between antennae and below median ocellus, temples narrow, ocell-ocular line not quite twice diameter of a lateral ocellus and shorter than postocellar line; labial palpus very slender, third segment nearly half as long as second; antennae 32-segmented, a little shorter than the body.

Thorax with notauli sharply impressed, finely punctate, mesonotal lobes and scutellum smooth, scutellar furrow foveate, propodeum strongly convex, without carinae, punctate, nearly smooth medially, sides of pronotum, and mesopleura, polished; mesopleural furrow long, nearly complete, finely foveolate; metapleurum punctate; radial cell on wing margin only about one-third as long as stigma; areolet minute, long-petiolate; mediella about equal to lower abscissa of basella; posterior tibia unusually slender on basal half, scarcely thicker at middle than at base, but distinctly enlarged apically, longer calcarium of posterior tibia hardly more than one-third as long as metatarsus.

Abdomen narrower than thorax; first tergite more than one and one-half times as long as broad at apex, without longitudinal keels, and smooth and

shining except for a little faint reticulation medially; remainder of abdomen polished, second tergite longer than third and with a very weakly indicated curved transverse impression at middle; ovipositor sheaths slightly longer than body.

Head and thorax black; abdomen reddish yellow, with first tergite more or less blackish; wings uniformly infumated; legs mostly yellowish; coxae black or blackish, posterior tibia mostly infuscated, with a pale yellow streak on inner side just before middle, middle and hind tarsi blackish

Male.—Essentially like the female; antennae of allotype also 32-segmented; posterior coxae red.

Type-locality.—Alamogordo, New Mexico

Type, allotype, and 10 *paratypes* in Academy of Natural Sciences of Philadelphia, 11 paratypes in U. S Nat. Museum (No. 44081, U S N. M)

Eight females and fifteen males collected in April and May, 1902. The paratypes exhibit some color variation, pronotum and mesonotum sometimes becoming more or less testaceous, abdomen occasionally dark reddish rather than reddish yellow, and, rarely, all coxae brownish yellow

Bassus parvus, new species

Most similar to *annulipes* (Cress), but differing especially in the black coxae, the lack of longitudinal carinae on propodeum, shorter antennae, strongly oblique areolet of anterior wing, more compact abdomen, and smaller size

Female —Length, 2 4 mm Head, as seen from in front, very short and broad, malar space short and very strongly inclined inwardly; eyes large; face much broader than long, third segment of labial palpus minute, scarcely discernible; antennae about as long as body, 25-segmented, temples swollen opposite middle of eyes, entire head polished.

Thorax a little narrower than head, mesonotum smooth and shining; notauli weakly impressed, punctate posteriorly, scarcely distinct anteriorly, propodeum punctate-rugulose without distinct carinae; mesopleurum polished, its furrow straight, indistinctly punctate; metapleurum shining, rugulose behind; posterior coxae polished, areolet of anterior wing minute, strongly petiolate, and oblique, second intercubitus very weak, mediella distinctly longer than lower abscissa of basella

Abdomen about as wide as thorax and scarcely longer, first tergite a little longer than broad, closely longitudinally striate, without distinct keels; remainder of abdomen polished, second tergite with a shallow transverse curved impressed line near middle, ovipositor sheaths slender, about one and one-half times as long as abdomen

Black; palpi piceous, all coxae black, all trochanters and femora brownish black; anterior and middle tibiae brownish; hind tibia blackish on apical half, yellowish basally, with an incomplete dark annulus a little beyond base; wings hyaline, stigma and veins dark brown

Male —Like the female in essential characters, antennae likewise 25-segmented

Type-locality —Palo Alto, California.

Type.—No 44082, U S. N. M

Three females and one male reared in the Bureau of Entomology by J. M. Miller (*Hopkins* 18244*c*), from an undetermined host infesting *Cupressus macrocarpa.*

Bassus reticulatus, new species

Very similar to *perforator* (Prov.), but separable by its coarsely rugoso-reticulate propodeum, shorter antennae, which are usually 20 to 22 segmented, and longer ovipositor sheaths, which are fully as long as the body.

Female.—Length, 4 mm Head rostriform, malar space nearly equal to eye height, nearly vertical, third segment of labial palpus about half as long as second; frons smooth, immargined; antennae but little longer than head and thorax combined, not tapering apically, 21-segmented in type.

Thorax deeper than wide, notauli wanting; mesonotum vertical in front; scutellum immargined; propodeum coarsely rugoso-reticulate, with a sharply defined median longitudinal impression from base to apex; posterior lateral angles of propodeum prominent, and the posterior declivity rather abrupt; side of pronotum faintly reticulate; mesopleurum smooth, its longitudinal furrow smooth; metapleurum minutely punctate or granular and subopaque; areolet triangular, moderately large, short-petiolate, radial cell on wing margin more than half as long as stigma; mediella about equal to lower abscissa of basella; posterior femora and tibiae short and stout.

Abdomen about as wide as thorax and slightly longer; first tergite large, about as broad at apex as long, entirely finely striato-granular, with two prominent longitudinal keels on basal half; second and third tergites transverse, subequal, closely granular and subopaque, each provided with a complete transverse groove at middle that is crossed by numerous longitudinal raised lines; second suture foveolate; third and following tergites smooth.

Honey-yellow; antennae, mesosternum, and propodeum except at apex, blackish, wings slightly brownish; legs mostly reddish yellow, trochanters, bases of anterior and middle femora, middle and posterior tibiae near base and at apex, and all tarsi, brownish black, second and third abdominal tergites with indefinite blackish markings laterally

Male.—Antennae 22-segmented; otherwise like the type

Type-locality.—Southern Illinois.

Type.—No 44083, U. S N. M.

Three females and one male collected by Charles Robertson. The antennae of both paratypes are 20-segmented and the thorax of one is entirely yellow.

Bassus brevicauda, new species

Most closely resembles *discolor* (Cresson), but differs especially in its shorter ovipositor and entirely black head and thorax

Female—Length, 3 mm. Head viewed from in front much broader than long, not rostriform; malar space less than half eye-height; antennae as long as body, slender, 35-segmented, third segment of labial palpus short but distinct; frons polished, immargined; ocell-ocular line slightly longer than postocellar line

Thorax rather stout; mesoscutum weakly punctate, notauli sharply impressed throughout; scutellum smooth; propodeum mostly horizontal, with only a very short posterior declivity, entirely closely rugulose but without carinae; mesopleura mostly smooth; mesopleural furrow long and distinctly foveolate, metapleura shagreened, opaque; posterior coxae faintly shagreened and subopaque outwardly, areolet of fore wing small, triangular, subpetiolate; radial cell on wing margin less than half as long as stigma; mediella slightly shorter than lower abscissa of basella.

Abdomen scarcely longer than thorax, broadening gradually to apex of third segment, first tergite completely uniformly granular and opaque, without

dorsal keels; second and third tergites much broader than long, sculptured like the first but more weakly, the third smooth at apex; fourth and following tergites polished; ovipositor sheaths not longer than abdomen, ovipositor decurved at apex.

Black; palpi pale; legs including all coxae testaceous; posterior tibia pale yellowish, broadly black at apex and with an incomplete blackish annulus near base; middle tibia weakly infuscated at apex and near base; all tarsi more or less blackish; wings uniformly brownish; second and most of third abdominal tergites reddish yellow; the following also reddish yellow laterally, except the last which is entirely blackish; venter of abdomen testaceous.

Type-locality.—Jefferson County, W. Va.

Type —No 44084, U. S. N. M

Host.—*Coleophora malivorella* Riley.

Two females reared in June and July, respectively, 1931, by Edwin Gould.

ZOOLOGY.—*A new species of* Pasiphaea *from the Straits of Magellan.*[1] WALDO L. SCHMITT, United States National Museum.

In the course of a brief review of the species of *Pasiphaea*, I thought that the doubts that have been raised from time to time regarding the true identity of *Pasiphaea acutifrons* Doflein and Balss, Mitteil. Nat. Mus. Hamburg, vol. 29, pt. 2, p. 27, fig. 1, should be settled by recourse to the original material. Through the kindness of Dr. A. Panning of the Zoologische Staatsinstitut and Zoologische Museum, Hamburg, Germany the specimens were entrusted to me for study. I find they represent an undescribed species.

Pasiphaea dofleini, new species

Pasiphaea acutifrons Doflein and Balss, Mitteil Nat. Mus , Hamburg, vol. 29, pt. 2, p 27, fig. 1 (Not *P. acutifrons* Bate)

A new species of *Pasiphaea* with very slightly emarginate telson, and non-carinated carapace and abdomen

The compressed carapace is very little less than half the length of the abdomen and without a trace of a mid-dorsal carina, except as the back of the gastric tooth itself may be called a short carina, the tip of that tooth falls short of the frontal margin. The branchiostegal spine is situated before the angle of the sinus and near the anterior margin of the carapace but does not seem to project beyond it; the branchiostegal sinus is quite shallow

The acicle inclusive of the spine is nearly half the length of the carapace and exceeds the antennular peduncle by about half the length of the last segment; the latter is about as long as the second and the visible portion of the first, before the eyes, taken together, the second joint is about twice as long as the visible portion of the first; the basal joint of the antenna carries a well developed spine beneath.

The meral joints of the first pair of legs are unarmed on their inferior margins, as are the ischia, the meral joints of the second legs have seven spines below in the type, but from an inspection of other specimens it appears that the count may vary from seven to ten; the basal joints, and the carpi of the second pair of legs are furnished at the infero-distal angle with a sharp

[1] Received May 7, 1932 Published by permission of the Secretary of the Smithsonian Institution

spine; the carpus of the first legs is acute and may be somewhat produced, but does not approach the spine-like process of the second carpus either in size or length. The distal margin of the first or basal joint of the antennular peduncle, the end of the antennal peduncle, and of the carpus of the second pair of legs all attain about the same level; the first carpi, though approximately subequal to the second, reach a little farther forward, as do the first meral joints. These relative forward extensions vary in some of the specimens; in one, a specimen smaller than the one taken as the type, the meri of the second legs attain the level of the distal margin of basal joint of the antennule and those of the first legs reach a little in advance of this point.

In the type specimen the palm of the second legs is shorter than the fingers, palm 4 mm long; longer, fixed or immovable finger 5½ mm. long; the chelae of the first pair are missing. In the first pair of legs of a smaller specimen the fingers are subequal and a little shorter than the palm, 3 2 mm. as compared to 4 mm for the palm

Approximate measurements of the type —Carapace 15 2 mm. long; abdomen inclusive of telson, 71 mm ; sixth abdominal somite, 8 mm , telson, 7 mm The type is in the Hamburg Museum

Type locality —Punta Arenas, now Magelhanes, Chile.

Remarks.—This species is at once differentiated from *P acutifrons* Bate and from *P. faxoni* Rathbun with which de Man thought it might prove identical, by the sharp longitudinal carination of the carapace, the more or less

Fig 1 —*Pasiphaea dofleini* —Outline of carapace of type

carinated abdomen, and the shape of the extremity of the telson which in the first named is distinctly forked and in *P faxoni* forms a not very deep, yet a decided inverted V.

P. forceps Milne Edwards, from the Straits of Magellan, though resembling *P dofleini* in its non-carinated carapace, is sharply differentiated by its deeply cleft telson.

From the species with which the present species might be considered to have something in common, *P. kaiwiensis* Rathbun and *P.* n. sp.? (*hilarula*) de Man, because of the very slightly emarginate telson and non-carinated carapace behind the gastric tooth itself, *P. dofleini* may be distinguished by the armature of the meral joints of the first and second legs In the first named the merus of the first pair of legs is armed with two small spines below and that of the second with fourteen spines; in de Man's "n sp ?" for which he proposed the name *hilarula* if sustained as a distinct species, the first merus carries a single small spinule at about the middle of the ventral margin, and the second merus three well developed spines.

P. emarginata Rathbun, whose telson exhibits a comparatively shallow Λ-shaped notch, has the carapace quite sharply carinated for the greater

part of its length and is armed with six to nine spines on the first merus, and seventeen to eighteen on the second. These spines are not all of the same size, a few are quite small, and appear with increase in size of the specimen and age to become more or less obsolescent and disappear, for in one fairly large specimen I could count but four spines on the first merus and eight on the second.

MALACOLOGY.—*The tree snails of the genus* Cochlostyla of *Mindoro Province, Philippine Islands.*[1] PAUL BARTSCH, United States National Museum.

Recent sendings of splendid collections of land shells made by Sr. Pedro de Mesa in Mindoro Province, Philippine Islands, have made it necessary to subject the Cochlostylas of the region to a critical study. This has been done, and the results are embodied in a fully illustrated monograph upon the group, submitted to the United States National Museum for publication. It seems, however, that an accumulation of manuscript will hold up its publication for some time, and since Mr. de Mesa is anxious to distribute the material, which he has collected, it appears best to publish a brief diagnosis of the new things discovered in this genus. I am therefore listing all the members of the genus so far known from the region, giving the distribution of each. A new subgenus and the new species and subspecies are tersely differentiated and their type with its United States National Museum number designated.

COCHLOSTYLA (CORASIA) AEGROTA Reeve Mindoro

COCHLOSTYLA (CALOCOCHLEA) MELANOCHEILA Grateloup. Eastern Mindoro.

Cochlostyla (Calocochlea) perpallida, new species This species resembles in size and hydrophanous marking *Cochlostyla melanocheila*, but the ground color of the nuclear whorls, aperture and peristome are white; the aperture and columella are also more oblique *Type*: U. S N M No 313568; Tubukala near San Teodora, northeastern Mindoro

COCHLOSTYLA (CALOCOCHLEA) ROISSYANA Ferussac. This species breaks up into a number of geographic races, some of which are new They are·

Cochlostyla (*Calocochlea*) *roissyana roissyana* Ferussac Northeastern Mindoro.

Cochlostyla (*Calocochlea*) *roissyana bartschi* Clench Anduyanan, Paluan, northwestern Mindoro

Cochlostyla (*Calocochlea*) *roissyana subatra* Pilsbry Mindoro

Cochlostyla (*Calocochlea*) *roissyana lutea* Pfeiffer Ilin Island, off southern Mindoro.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received May 10, 1932.

Cochlostyla (Calocochlea) roissyana cavitala, new subspecies. This race differs from *Cochlostyla* (*Calocochlea*) *roissyana bartschi* Clench in being uniformly lighter colored. *Type:* U. S. N. M. No. 313589; Mt. Calavite near Paluan, northwestern Mindoro.

Cochlostyla (Calocochlea) roissyana manlaysa, new subspecies. This race is distinguished from typical *roissyana* Ferussac by its much paler color. *Type:* U. S. N M. No. 313614; east shore of Mansalay Bay, eastern Mindoro.

Cochlostyla (Calocochlea) roissyana laymansa, new subspecies. This race, specimens of which I collected on the west shore of Mansalay Bay, eastern Mindoro, can readily be distinguished by its pale greenish plum color. *Type:* U. S. N. M. No. 255958.

COCHLOSTYLA (CALOCOCHLEA) GERTRUDIS Möllendorff, Kobelt and Winter. Bongabon, southeastern Mindoro

Cochlostyla (Halocochlea) lillianae, new subgenus and species. Shell helicoid, periphery angulated, curve between summit and periphery of last whorl equalling that of base between periphery and umbilicus; peristome expanded and reflected; columella very oblique and excavated. There is scarcely any calcareous material in the shell, which is thin and diaphanous, and of very pale yellowish olive green color, with a dark chestnut brown columellar area. *Type* U. S. N. M No 255825; Mt Halcon.

COCHLOSTYLA (HELICOSTYLA) FULGENS FULGENS Sowerby Northeastern Mindoro.

Cochlostyla (Helicostyla) fulgens johnsoni, new subspecies. This subspecies is readily distinguished from the other two by its more elevated spire It has the dark base and variable bands of typical *Cochlostyla* (*Helicostyla*) *fulgens fulgens*. *Type:* U. S. N. M. No 21779; Sitio Pamulon, Mansalay Bay, southeastern Mindoro

Cochlostyla (Helicostyla) fulgens sapolana, new subspecies. This subspecies is distinguished from typical *Cochlostyla* (*Helicostyla*) *fulgens fulgens* by its lacking the dark olivaceous yellow base. Here it is only a trifle more yellow than the spire. *Type:* U. S N. M No 313574; Mt Sapol, northeastern Mindoro.

COCHLOSTYLA (HELICOSTYLA) DIMERA Jonas. Mindoro.

COCHLOSTYLA (COCHLOSTYLA) HYDROPHANA HYDROPHANA Sowerby. Medio Island, Mindoro.

Cochlostyla (Cochlostyla) hydrophana veroderoana, new subspecies. This subspecies is readily distinguished from typical *Cochlostyla* (*Cochlostyla*) *hydrophana hydrophana* by its much more elevated form. *Type:* U. S. N. M. No. 313619; Verodero, Mindoro.

COCHLOSTYLA (COCHLODRYAS) FLORIDA FLORIDA Broderip. Northeastern Mindoro.

COCHLOSTYLA (COCHLODRYAS) FLORIDA FUSCOLABIATA Möllendorff, Kobelt and Winter. Mindoro.

Cochlostyla (Cochlodryas) florida aureola, new subspecies This race in shape reminds one of *Cochlostyla* (*Cochlodryas*) *florida signa*, but can at once be differentiated from this by its golden yellow periostracum *Type* U S N. M No 313610, obtained by the U S Exploring Expedition, probably at the southern tip of Mindoro

Cochlostyla (Cochlodryas) florida signa, new subspecies This subspecies is differentiated from all the others by its exceedingly thin shell and pale olivaceous waxy coloration *Type* U S N M No 313611, west shore of Mansalay Bay, southeastern Mindoro

COCHLOSTYLA (COCHLODRYAS) FLORIDA HELICOIDES Pfeiffer Northeastern Mindoro

COCHLOSTYLA (COCHLODRYAS) ORBITULA Sowerby Northeastern Mindoro

Cochlostyla (Cochlodryas) mateoi, new name for HELIX TENERA Sowerby, 1841, Proc Zool Soc , p 102, in part, not HELIX TENERA Gmelin, 1791, Linn Syst Nat , ed 13, vol 1, pt 6, p 3653 The dark banded shell Northeastern Mindoro

Cochlostyla (Cochlodryas) mateoi sibolonensis, new subspecies This can readily be distinguished from typical *Cochlostyla* (*Cochlodryas*) *mateoi* by its very thin shell and broad form, as well as paler coloration *Type* U S N M No 313629, Sibolon Island off southeastern Mindoro

Cochlostyla (Cochlodryas) fastidiosa, new name for HELIX TENERA Sowerby, 1841, Proc Zool Soc London, p 102, in part, not HELIX TENERA Gmelin Linn Syst Nat ed 13, 1791, vol 1, pt 6, p 3653 The pale shells Northeastern Mindoro

COCHLOSTYLA (COCHLODRYAS) DECORA Adams and Reeve Mindoro

COCHLOSTYLA (COLUMPLICA) CEPOIDES Lea Lubang Island

COCHLOSTYLA (HELICOBULINUS) TURBO Pfeiffer Mindoro

Cochlostyla (Orthostylus) euconica, new species Shell broadly conic, periostracum varying from grayish brown to wood brown Where the periostracum is removed, the early whorls are flesh colored, the succeeding turns becoming gradually darker until the last is chestnut brown between summit and periphery and bright dark chestnut brown on base Aperture bluish white, peristome edged with brown, columella pinkish *Type* U S N M No 313637, Calapan, Mindoro It has 5 7 whorls, and measures Length, 50 3 mm , greater diameter, 39 2 mm , lesser diameter, 34 mm

COCHLOSTYLA (HYPSELOSTYLUS) CINCINNIFORMIS CINCINNIFORMIS Sowerby Lubang Island

COCHLOSTYLA (HYPSELOSTYLUS) CINCINNIFORMIS ULTIMA Clench Aparico, Golo Island

COCHLOSTYLA (HYPSELOSTYLUS) CINCINNIFORMIS DEMESANA Clench. Aparico, Golo Island

Cochlostyla (Hypselostylus) cincinniformis menagei, new subspecies. This subspecies is distinguished from the others by its much more vivid coloration, the light areas being much more intensely white and the dark areas equally intensely dark, but the dark areas are not as broad as in typical *Cochlostyla* (*Hypselostylus*) *cincinniformis cincinniformis*; consequently the shell as a whole appears paler than in the typical race *Type*: U. S. N. M. No. 313578; collected by the Menage Expedition in northeastern Mindoro.

Cochlostyla (Hypselostylus) cincinniformis guntingana, new subspecies. The yellow or orange coloration of the light areas in this subspecies will distinguish it from the rest. *Type:* U. S. N. M No. 313574; Gunting Mountain, Looc Bay, Lubang Island.

Cochlostyla (Hypselostylus) cincinniformis cabrasensis, new subspecies. This subspecies is distinguished from the rest by having the brown bands much brighter and the light ones intensely bluish white. *Type:* U. S. N. M. No. 313639; Cabras Island

COCHLOSTYLA (HYPSELOSTYLUS) CINCINNIFORMIS LUBANENSIS Clench and Archer Binacas, Lubang Island.

COCHLOSTYLA (EUDOXUS) JONASI Pfeiffer. Mindoro

COCHLOSTYLA (EUDOXUS) BUSCHI Pfeiffer Mindoro

COCHLOSTYLA (EUDOXUS) SIMPLEX Jonas. Mindoro

COCHLOSTYLA (EUDOXUS) ALBINA Grateloup Mindoro

Cochlostyla (Eudoxus) canonizadoi, new species This species suggests very strongly *Cochlostyla* (*Cochlodryas*) *halichlora* Semper from Luzon, but it is in every way much smaller. *Type* U S. N M. No. 313722; 5 whorls; measures: Length, 27 3 mm ; greater diameter, 27 9 mm , lesser diameter, 22 5 mm ; Sibolon Island, south of Mindoro.

COCHLOSTYLA (PROCHILUS) VIRGATA Jay. This is a most interesting mutating species, which I have fully discussed in my monograph and some of whose forms have been described as: BULIMUS PORRACEUS Jay, BULIMUS LABRELLA Grateloup, BULIMUS DRYAS Broderip, BULIMUS SYLVANUS Broderip, BULIMUS CALOBAPTUS Jonas, BULIMUS CUYOENSIS Reeve, in part, COCHLOSTYLA SYLVANOIDES Semper, COCHLOSTYLA VIRGATA PULCHRIOR Pilsbry, COCHLOSTYLA VIRGATA ALAMPE Mollendorff. Northeastern Mindoro.

Cochlostyla (Prochilus) cerina, new species The medium-size and yellow color will distinguish this species from all others of the subgenus. *Type* U. S N. M No 313672; Bulalacao, southeastern Mindoro.

COCHLOSTYLA (PROCHILUS) PARTULOIDES Broderip. Northeastern Mindoro.

COCHLOSTYLA (PROCHILUS) CUYOENSIS CONTRACTA Möllendorff. Mindoro

Cochlostyla (Prochilus) cuyoensis subpallida, new subspecies. This subspecies differs from *Cochlostyla* (*Prochilus*) *cuyoensis contracta* Möllendorff in its exceedingly thin shell which permits all of the interior to be seen by

transmitted light, and in lacking the decided color bands *Type*· U. S. N M No. 313671; Caluya Island, off southeastern Mindoro

Cochlostyla (Prochilus) fictilis fulva, new subspecies This subspecies differs from all the others known by being yellowish but in having a remnant of the basal columellar dark area This is based upon Mollendorff, Kobelt and Winter's description and figure of *Cochlostyla (Prochilus) fictilis larvatus,* 1914, Semper's Reisen im Archipel der Philippinen, vol X, p. 332, in part, pl. 76, figs 11, 12. Southeastern Mindoro.

Cochlostyla (Prochilus) fictilis ambulonensis, new subspecies This subspecies is rather large and has the white band at the summit of the whorls reduced to a minimum. *Type* U S N M No 313600; Ambulon Island off southwestern Mindoro

Cochlostyla (Prochilus) fictilis marmorosa, new subspecies This is similar to *Cochlostyla (Prochilus) fictilis ambulonensis,* but is much smaller and brighter colored The light band at the summit is also much broader. *Type*· U S N. M. No 313741; Ilin Island, off southwestern Mindoro Its geographic position is intermediate between that of *Cochlostyla (Prochilus) fictilis ambulonensis* and *Cochlostyla (Prochilus) fictilis cagurana* and so is its color scheme

Cochlostyla (Prochilus) fictilis cagurana, new subspecies This subspecies is easily distinguished from the other Mindoro *fictilis* by its dark coloration and very broad light band at the summit *Type* U S N M No 313598; Caguray, southwestern Mindoro

COCHLOSTYLA (CHRYSALLIS) CHRYSALIDIFORMIS CHRYSALIDIFORMIS Sowerby Northeastern Mindoro.

Cochlostyla (Chrysallis) chrysalidiformis macra, new subspecies The extreme slenderness of this subspecies will distingush it from all the others. *Type* U S N M No 382969, Mindoro

Cochlostyla (Chrysallis) chrysalidiformis villosa, new subspecies This subspecies in shape and sculpture resembles most nearly typical *Cochlostyla (Chrysallis) chrysalidiformis chrysalidiformis,* but it is a little more rough and lacks the dark color band at the summit and the dark edge to the lip. It differs from *Cochlostyla (Chrysallis) chrysalidiformis enodosa* by its larger size, more elongate form and stronger sculpture *Type* U S N M No 315858; Mindoro

Cochlostyla (Chrysallis) chrysalidiformis rarior, new subspecies. The subspecies is remarkable for the extreme thinness of its shell *Type.* U. S N M. No. 313644, Calawagan, Paluan, northwestern Mindoro.

Cochlostyla (Chrysallis) chrysalidiformis enodosa, new subspecies This subspecies is nearest related to *Cochlostyla (Chrysallis) chrysalidiformis villosa,* from which it can be easily distinguished by its more ovate form and much more less strongly developed sculpture. *Type* U S. N. M. No. 382970; southwestern Mindoro

Cochlostyla (Chrysallis) chrysalidiformis fuscata, new subspecies. This differs from all the other subspecies by its regularly conic spire and by having the parietal wall brown. *Type:* U. S. N. M. No. 382971; Mindoro.

Cochlostyla (Chrysallis) jayi, new name for BULIMUS USTULATUS Jay, 1839, Cat. Shells, 2d ed , p 119, pl 6, fig. 1; not BULIMUS USTULATUS Sowerby, 1833, Conchological Illustrations, figure 42.

Cochlostyla (Chrysallis) jayi jayi, new name Northeastern Mindoro

Cochlostyla (Chrysallis) jayi perpusilla, new subspecies This subspecies differs from typical *Cochlostyla (Chrysallis) jayi jayi* in being much smaller. *Type:* U S N. M. No. 313685; Calawagan, Paluan, northwestern Mindoro.

Cochlostyla (Chrysallis) jayi camorongana, new subspecies. In this subspecies the ground color is blackish brown, while in the others it is bright chestnut brown *Type.* U. S N. M No. 313620; Camorong, Abra de Ilog, northern Mindoro.

COCHLOSTLYA (CHRYSALLIS) LICHENIFER LICHENIFER Mörch. Mindoro

Cochlostyla (Chrysallis) lichenifer avittata, new subspecies. This differs from typical *Cochlostyla (Chrysallis) lichenifer lichenifer* by lacking the peripheral brown band *Type.* U S. N. M No. 382972 is from Mt Halcon.

COCHLOSTYLA (CHRYSALLIS) ELECTRICA ELECTRICA Reeve Puerta Galera, northeastern Mindoro

Cochlostyla (Chrysallis) electrica mangarina, new subspecies This subspecies differs from typical *Cochlostyla (Chrysallis) electrica electrica* in being more globose and in having the axial fulguration slanting retractively It differs from *Cochlostyla (Chrysallis) electrica bulalacaoana* in being more globose and in having a less strong periostracum. *Type* U. S. N. M No. 382973; Sitio Brucaan, Mangarin, southwestern Mindoro

Cochlostyla (Chrysallis) electrica bulalacaoana, new subspecies This subspecies differs from *Cochlostyla (Chrysallis) electrica mangarina* in being less globose and in having a much stronger periostracum. *Type:* U. S N M. No 382974; Bo. de Cora, Bulacao, southeastern Mindoro

Cochlostyla (Chrysallis) palliobasis, new species This species is most conspicuously distinguished from all the other *Cochlostyla (Chrysallis)* by having the basal half pale buff, contrasted with the chestnut coloration of the upper part of the last whorl *Type* U S N. M No 313653; Pinagbayan, Paluan, Mindoro.

Cochlostyla (Chrysallis) pettiti, new name for BULIMUS CAILLIAUDI Pettit, December, 1850, Journ Conchyl , vol 1, p 404, pl 13, fig 3, not BULIMUS CAILLIAUDI Pfeiffer, August, 1850, Zeitschr Malakozo. p. 86.

COCHLOSTYLA (CHRYSALLIS) ROLLEI ROLLEI Möllendorff North base of Mt. Halcon, Mindoro

Cochlostyla (Chrysallis) rollei osborni, new subspecies. This subspecies differs from typical *Cochlostyla (Chrysallis) rollei rollei* in having the shell

much more ovate and the axial bands much broader. *Type:* U S. N. M. No. 300823; Lake Naujan, Mindoro.

Cochlostyla (Chrysallis) rollei vexator, new subspecies This subspecies is ever so much smaller than typical *Cochlostyla* (*Chrysallis*) *rollei rollei*. *Type:* U. S. N. M. No. 104348; Mindoro.

Cochlostyla (Chrysallis) rollei niger, new subspecies. This subspecies differs from the other three in being ever so much darker and in having the spiral sculpture more pronounced *Type*· U S N. M. No. 313721; Mayabig, Baco, Mindoro.

Cochlostyla (Chrysallis) albolabris, new species This species is most nearly related to *Cochlostyla* (*Chrysallis*) *rollei* from which it differs in having the peristome white and the aperture proportionately larger It is also much smaller. There are two races before me which may be called:

Cochlostyla (Chrysallis) albolabris albolabris, new subspecies In this the shell is of elongate-ovate shape *Type*· U. S N. M No. 104347; Mindoro.

Cochlostyla (Chrysallis) albolabris robusta, new subspecies. In this the shell is not elongate-ovate but ovate *Type.* U. S. N. M. No 104346; Mindoro.

COCHLOSTYLA (CHRYSALLIS) ANTONI ANTONI Semper. Northeastern Mindoro.

Cochlostyla (Chrysallis) antoni macilenta, new subspecies. This subspecies can readily be distinguished from *Cochlostyla* (*Chrysallis*) *antoni antoni* by its much more slender form *Type:* U. S. N. M. No. 313551; Sitio Boncaan, Mangarin, southwestern Mindoro

Cochlostyla (Chrysallis) roseolabra, new species Shell varying from elongate conic to broadly ovate General color yellowish buff or wood brown. Interior of aperture bluish white or bluish white with a purplish tinge; peristome pale or bright rose colored. There are two subspecies before me:

Cochlostyla (Chrysallis) roseolabra roseolabra, new subspecies. In this the general color of the shell is yellowish buff, while the expanded peristome is pale rose colored *Type:* U S N M No 313677; Calawagan, northwestern Mindoro.

Cochlostyla (Chrysallis) roseolabra rosea, new subspecies In this the general color scheme is wood brown. The periostome is much more intensely rose colored. *Type*· U. S. N. M. No. 133680; interior from Abra de Ilog, northern Mindoro.

COCHLOSTYLA (CHRYSALLIS) ASPERSA ASPERSA Grateloup. Northeastern Mindoro

Cochlostyla (Chrysallis) aspersa lunai, new subspecies. This is the largest subspecies, suggesting in size *Cochlostyla* (*Chrysallis*) *rollei*, from which it

can be at once distinguished by its dark apex. *Type:* U. S. N. M. No. 313702; Calamintao, Mamburo, Mindoro.

Cochlostyla (Chrsyallis) aspersa juani, new subspecies This is the smallest of the short based subspecies. *Type:* U. S N. M. No 313708; Camorong, Abra de Ilog, northern Mindoro.

COCHLOSTYLA (CHRYSALLIS) ASPERSA MINDOROENSIS Broderip. Dulugan, Puerto Galera, northeastern Mindoro

COCHLOSTYLA (CHRYSALLIS) ASPERSA MELANOGASTER Mörch. Mt. Sapol northeastern Mindoro

COCHLOSTYLA (CHRYSALLIS) ASPERSA WAGNERI Grateloup About Lake Naujan, eastern Mindoro

Cochlostyla (Chrysallis) aspersa edgari, new subspecies This is the large, elongate-ovate race with rather protracted base about the east slope of Mt. Halcon. The axial bands of brown and buff are distinct and rather broad, and not interrupted at the periphery. *Type:* U. S. N. M No. 313712

Cochlostyla (Chrysallis) aspersa binuangana, new subspecies This subspecies is very dark colored and of ovate form. It suggests *Cochlostyla (Chrysallis) aspersa melanogaster* but lacks the dark basal coloration. *Type:* U. S. N M No 313713, Binuanga, Paluan, northwestern Mindoro

Cochlostyla (Chrysallis) aspersa ilogana, new subspecies This subspecies is readily distinguished from *Cochlostyla (Chrysallis) aspersa edgari* by its much more regular elongate-ovate form and from *Cochlostyla (Chrysallis) aspersa calavitana* by its much greater size *Type* U. S N M. No 313706; Camorong, Abra de Ilog, northern Mindoro

Cochlostyla (Chrysallis) aspersa calavitana, new subspecies This subspecies can readily be distinguished from the other members of the group with protracted base by its exceedingly small size *Type* U S N. M. No 313714; Mt. Calavite near Paluan, northwestern Mindoro

Cochlostyla (Chrysallis) caniceps, new species In this species the shell varies from elongate-ovate to elongate-conic The nuclear whorls are flesh colored. Postnuclear whorls marked by axial bands and fulgurations of yellow or greenish yellow Interior of aperture bluish white; peristome varying from white to brown in the different subspecies. Distribution apparently all over Mindoro, breaking up into a number of subspecies

Cochlostyla (Chrysallis) caniceps demesai, new subspecies. This subspecies is much darker than any of the other subspecies. Here the dark color of the periostome extends within the aperture, a feature not possessed by the other races *Type.* U. S N. M. No 313552; Calamintao, Mamboro, northwestern Mindoro.

Cochlostyla (Chrysallis) caniceps maita, new subspecies This subspecies belongs to the ovate-conic group and most nearly resembles *Cochlostyla (Chrysallis) caniceps contracostana*, but it is much larger and the peristome is much darker. *Type·* U. S N. M. No. 20351a; southern tip of Mindoro.

Cochlostyla (Chrysallis) caniceps contracostana, new subspecies This subspecies belongs to the elongate-ovate group and can readily be distinguished from *Cochlostyla (Chrysallis) caniceps demesai* by its smaller size and less brilliant coloration, and from *Cochlostyla (Chrysallis) caniceps maita* by its smaller size. *Type.* U. S N. M No 313554; Contra Costa, Mindoro.

Cochlostyla (Chrysallis) caniceps conica, new subspecies The regularly conic outline will distinguish this subspecies from all the others *Type.* U S. N M. No 313555; southwestern Mindoro

Cochlostyla (Chrysallis) caniceps caniceps, new subspecies In this subspecies the shell is elongate-conic, the whorls are well rounded It is nearest related to *Cochlostyla (Chrysallis) caniceps minuta*, but is much larger than that subspecies *Type:* U S N. M No. 313556, Lake Naujan, Mindoro

Cochlostyla (Chrysallis) caniceps minuta, new subspecies This subspecies is most nearly related to the typical race *Cochlostyla (Chrysallis) caniceps caniceps*, but is easily distinguished from it by its smaller size and more shaggy sculpture. *Type.* U. S N. M. No 313560, Mansalay, southeastern Mindoro.

Cochlostyla (Chrysallis) nigriceps, new species. The members of this species closely resemble *Cochlostyla (Chrysallis) caniceps* from which, however, they can be distinguished at once by their dark nuclear turns.

Cochlostyla (Chrysallis) nigriceps nigriceps, new subspecies This subspecies is nearest related to *Cochlostyla (Chrysallis) nigriceps nubifer*, from which it is distinguished by its lesser size. *Type·* U S N M. No. 313716, Lake Naujan, northeastern Mindoro

Cochlostyla (Chrysallis) nigriceps nubifer, new subspecies This subspecies is nearest related to *Cochlostyla (Chrysallis) nigriceps nigriceps*, from which its larger size will readily distinguish it *Type* U. S N. M. No 195408; southwestern Mindoro

Cochlostyla (Chrysallis) nigriceps obnubila, new subspecies. This subspecies is readily distinguished from the other two by having the general color blackish brown instead of chestnut brown. The hydrophanous cloudings are also lighter and much more pronounced *Type* U. S N M. No. 313718; Binuangan, Paluan, northwestern Mindoro

Cochlostyla (Chrysallis) perturbator, new species Shell of medium size, ovate. Early nuclear whorls white, grading slowly into the brown of the postnuclear turns. Periostracum of the postnuclear whorls moderately thick, covered by hydrophanous bands, cloudings or fulgurations of olivaceous buff between which the dark ground color shines through On the last whorl the periostracum is almost completely hydrophanous Interior of the broadly oval aperture pale blue; periostracum and inner lip chocolate brown, with an iridescent flush. *Type·* U. S N M No. 313720; Tara, Abra de Ilog, northern Mindoro

Cochlostyla (Chrysallis) corrugata, new species. In this species the nuclear

whorls are flesh colored; the early postnuclear whorls are buff, while the later ones gradually range to very dark chestnut brown. The postnuclear whorls are conspicuously marked by brilliant fulgurations of yellowish buff, which are most pronounced near the summit of the shells. The interior of the aperture and inner portion of the columella are pale blue, gradually grading to purplish brown at the edge of the expanded peristome and inner lip The most distinctive feature of the shell, however, is the axial corrugations of the last, and sometimes the penultimate, whorl *Type:* U. S. N. M. No. 313740; San Jose, southwestern Mindoro

ZOOLOGY.—Metoncholaimus pristiurus (*zur Strassen*); *a nema suitable for use in laboratory courses in zoology.*[1] N. A. COBB, U. S. Department of Agriculture.

Zur Strassen, who first proposed the species *Metoncholaimus pristiurus*, alluded for the most part only to the organs whose forms served to distinguish it from its nearest allies among the oncholaims. The present attempt at a more complete understanding of its morphology adds to our knowledge in a number of ways, especially with regard to the remarkable demanian system.

At the same time the text and figures have been prepared with particular reference to requests of school, college and university instructors in invertebrate zoology, a course suggested by the fact that this species has been used with some promise of success in the invertebrate courses of a considerable number of universities.

Unfortunately few if any zoological textbooks treat nemas adequately. It is believed that any progressive and well equipped instructor who will study carefully the following descriptions, with the aid of good *living* as well as preserved specimens, will find himself all the better equipped to instruct students concerning the morphology of the important nemic phylum.

METONCHOLAIMUS PRISTIURUS (Zur Strassen)

[*Meta*, changed; *Oncholaimus*, tooth (in the) throat]

FEMALE. Fig 1

The cuticle and the body wall $\frac{0.8}{0.8}\ \frac{3.9}{1.3}\ \frac{12.}{1.4}\ \frac{51\cdot65}{1.5}\ \frac{90.2}{0.8}$ 3.6 mm
The *contour* of the nema is plain. The thin, transparent, colorless, nearly naked cuticle, 72, 96, about one micron thick, is traversed by plain transverse striae; but these are very difficult of resolution except with high powers of the microscope used skillfully under favorable conditions,—ordinarily they will

[1] Through the much appreciated courtesy of the United States Bureau of Fisheries a considerable part of these investigations was carried out at its Laboratories at Woods Hole, Mass Received May 18, 1932

not be seen. These striae are not altered on the lateral fields; there are no longitudinal wings. The subcuticle, 99, usually contains multitudinous pebbly,—i.e. roundish or slightly elongate,—*yellowish pigment granules*, 34, 82, 95, one to two microns across, "paved" in longitudinal bands of variable width;—two broad lateral bands, one on each side of the body, about one-third as wide as the nema and having narrower submedian bands on each side; and three narrow ventral bands as well as even narrower dorsal bands. These bands are better seen after staining over night in *seawater-methylene-blue*, which may not only stain them but bring out the fact that the granules along the edges of the two main lateral bands are of a somewhat different nature from the rest *Longitudinal striations* in the subcuticle, due to the attachment of the musculature, 4, 16, 77, are faintly visible at high magnification in most regions of the body, especially the more translucent parts. The body wall, including the cuticle, is about six microns thick

Ten widely spreading *cephalic setae*, 26, are arranged on the lateral surface of the lip region in the usual way, i e a pair on each submedian line and one on each lateral line; the longest of these are one-fourth as long as the corresponding portion of the head is wide, the shorter member of each submedian pair being about three-fourths as long as the longer The members of the submedian pairs grow so close together as sometimes to appear as one These subcylindroid setae are nearly straight and are blunt at the end, where they seem more or less *open*, not closed, indicating, probably, that they may also be connected with some sense in addition to that of touch. There are a few scattered subcephalic setae near the head, of nearly the same length (ten to twelve microns) as the cephalic setae, but more slender On the neck and on the body there are also a few scattered setae,—very inconspicuous and seldom seen. There are also a few very short, *very inconspicuous setae* on the tail, especially toward its extremity and *on the spinneret*, 24, 74 There are no cuticular pores

The neck and head. The head and neck occupy the anterior 11 to 13 per cent of the body, i e the part in front of the prominent constriction, 13, between the nearly colorless oesophagus, 12, 36, and the darker intestine, 83, 94. The slightly conoid *neck* ends in a *subtruncate continuous head*, the frontal mouth opening in which is not depressed In front the *pharynx*, 31, 48, 57, is arched over by the six distinct and separate, flat and thin, fairly well developed, mobile *lips*, 28, 49, which are not set off by constriction or in any other way As a rule the lips are not readily counted except when seen from in front Toward the margin of the head there is a circlet of six, innervated, very minute and inconspicuous, *forward-facing sensory papillae*, 29, 45, one on each lip. This circlet is about two-thirds as wide as the front of the head These papillae also are rather difficult to see except from in front, 45 The rather simple subregular *pharynx*, 31, 35, 48, 57, about forty by twenty-three microns, is somewhat cylindroid anteriorly and vaguely conoid posteriorly The *posterior "chamber,"* 35, sixteen by nine microns, supports the *three acute onchia*, 25, 33, 53, the forward pointing projection of the largest of which is very readily seen Taken as a whole the pharyngeal cavity might be described as somewhat convex-conoid Its refractive, cuticularized wall is nearly two microns thick

Its armature consists of three unequal, conoid, perforated, pointed onchia, *one dorsal*, 25, *two ventrally submedian*, 33, 53 Of these the grooved left ventral submedian, 27, 53, is much the largest, and reaches two-thirds the distance to the lips. The other two, *e g* 33, 25, nearly equal in size, reach only about halfway to the lips Each onchium is the outlet of a branched and

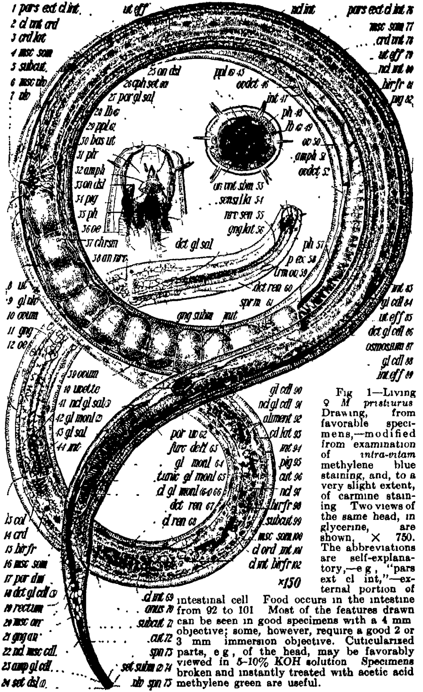

Fig 1—Living ♀ *M pristiurus* Drawing, from favorable specimens,—modified from examination of *intra-vitam* methylene blue staining, and, to a very slight extent, of carmine staining Two views of the same head, in glycerine, are shown, × 750. The abbreviations are self-explanatory,—e g , "pars ext cl int,"—external portion of intestinal cell Food occurs in the intestine from 92 to 101 Most of the features drawn can be seen in good specimens with a 4 mm objective; some, however, require a good 2 or 3 mm immersion objective. Cuticularized parts, e g , of the head, may be favorably viewed in 5–10% KOH solution Specimens broken and instantly treated with acetic acid methylene green are useful.

much elongated *unicellular salivary gland*, e g. 43, and *dct gl sal*, located along the corresponding sector of the oesophagus and reaching back even to near the base of the neck, where the corresponding three nuclei, 41, may be seen, about one body-width in front of the prominent constriction, 13, separating the oesophagus from the intestine. Each gland empties through a perforation, 27, in the corresponding onchium, by means of an inconspicuous *ampulla* and a *very fine duct*,—about one micron across. The distribution of the salivary glands among the radial contractile fibers of the oesophagus may be indicated by the granules, one micron or less in diameter, to be seen in various parts of the glands, e g at *dct gl sal* In favorable specimens the ducts of these glands, when filled with this granular secretion, can be followed throughout the length of the oesophagus, and the glands are then seen to have numerous short lateral branches, (see from 43 forward) The much larger, though inconspicuous *pigment granules of the oesophagus* are *scattered* throughout the organ.

The external *amphids*, 32, 51,—one on each side of the head,—are somewhat escutcheon shaped, being symmetrical only to a longitudinal line, and are longer transversely than longitudinally The anterior border of each amphid is removed from the anterior extremity of the nema a distance about equal to the radius of the head They are much more obvious if looked at dorso-ventrally, when they are distinctly seen to be two pocket-like entrances to internal sensory organs, the internal amphids, located laterad in the back part of the head Each of the external amphids is about one-fourth as wide as the corresponding portion of the head and about two-thirds as long as it is wide Each outer amphid connects with a *sensilla*, 54, or *receptor*, close behind, by means of an exceedingly narrow and very short (two and a half microns) but strongly refractive, duct, shown in the figure The sensilla is one-fifth as wide as the head and lies opposite the basal part of the pharynx and is connected backward with the central nervous system by a lateral nerve, 55, just beneath the body wall The details of the sensilla, 54, are usually difficult to see except when specially stained The amphids are held to be chemical sense organs

The *oesophagus*, 12, 36, is cylindroid, enlarging very slightly posteriorly, behind the pharynx it is three-fifths, at the nerve-ring one-half, and finally two-thirds as wide as the corresponding portion of the neck The refractive membranous "triquetrous" *lining of the eosophagus*, mainly about one micron thick, but two microns in the axial parts, is a distinct feature throughout the organ, and finds *main optical expression* in what appear as two or three closely approximated refractive, often slightly sinuous, axial elements, and, in the ordinary closed condition of the oesophagus, seeming to occupy about one-eighth of its width The radial *musculature of the eosophagus*, to be seen throughout its length, consists of fine strands and is accompanied by only a slight amount of yellowish granular matter There are no cuticularized valves in the oesophagus

The intestine. The *intestine*, 83, 94, which becomes at once two-thirds as wide as the body, is thick-walled and is composed, as is usual in nemas, of a *single layer of cells*, 69 and vicinity, here of such a size that about twelve are required to complete the circumference The walls of the cells are only faintly visible except sometimes in the outer colorless part, 1, 76 Usually the lumen of the intestine, (see just behind cardia, 14) can be seen only faintly, since the lining of the intestine is not refractive As the nema bends back and forth, the food content of the intestine, *e g.* at 92, may be seen to move backward and forward in the lumen. This nema appears to swallow mud

rather indiscriminately, and to extract its nutriment from a variety of organic material contained in the mud. Large quantities of this food material in the intestine may interfere with microscopic examination; hence the advisability of keeping the nemas in clean cool seawater for a day or two before examination. The *cardiac collum*, or constriction, 13, between the oesophagus and intestine, is about two-fifths as wide as the base of the neck, making a very obvious demarcation between the oesophagus and the intestine. There is a conoid *cardia*, 14, about two-fifths as wide as the base of the neck; this is the very short extension of the oesophagus into the intestine, and is composed of numerous smaller cells of a distinct kind, having to do, among other things, with the prevention of regurgitation. Though small, the cardia is a very important part of the alimentary canal. The outer portion of the intestine, 1, 76, is usually more or less *destitute of granules*, but the inner and greater portion of each intestinal cell contains globular yellowish *granules*, 69, of variable size, the largest of which are about three microns in diameter, and the smallest less than one micron. These granules are varied and numerous, sometimes are even packed close together, and may be so arranged in the cells as to give rise to a faint, or sometimes a quite distinct, tessellated effect.

The intestine is made up of *cells of different kinds*,—discharging different functions One of these various kinds is readily made out, especially with the aid of polarized light, namely the cells, as many as one hundred in number or even more, containing the exceedingly minute *birefringent granules* These cells, 15, 81, 98, when examined by ordinary transmitted light, present a finer texture internally, and usually are more distinctly yellowish If a suitable specimen be allowed to remain in a concentrated solution of seawater-methylene-blue a few minutes, a differential staining of the "birefringent" cells will often occur, but the effect does not last The "birefringent" cells are everywhere less numerous than those that do not contain birefringents, and there are *none of them at all* in the posterior part of the intestine. We may therefore speak of two distinct intestinal regions, one fore, one aft. The "birefringent" cells occur in early ovic embryos

The rather prominent short *rectum*, 19, the rear part of the intestine, is somewhat cuticularized, and is about as long as the anal body diameter; from the somewhat depressed *anus*, 70, it extends inward and forward at an angle of about forty-five degrees Its structure in the female differs somewhat from that of the male, which appears "helical" The anterior and posterior lips of the anus are of about equal size. Small inconspicuous somewhat pear-shaped unicellular *anal glands* can sometimes be seen, lying alongside the rectum with their narrowed necks directed toward the anus.

Tail and spinneret. The slightly arcuate *tail* is first conoid, then cylindroid in the posterior fourth, where it ends in a somewhat blunt, almost imperceptibly swollen, rounded spinneret, 73, armed only with three exceedingly inconspicuous setae, two ventrally submedian, 74, and a dorsal one, 24. Though insignificant in appearance these sensory setae are important. The very nearly symmetrical spinneret displays internally the three very slightly swollen *ampullae of the three caudal glands*, 23. The *spinneret valve*, or plug, 75, four microns across, almost at the very end of the tail, stains green with methylene blue ("intra vitam") while other nearby parts stain blue. This *important valve* is hemispherical posteriorly and tapers anteriorly to a fine *contractile element*, shown white in the drawing, fastened in the midst of the three ampullae (23) It is by the contraction of this minute fiber that the plug or valve is pulled away from its seat, so as to permit the sticky, non-water soluble,

cement-like secretion of the three caudal glands to pour outward to be used in temporarily cementing the nema by the tail to the substratum in a versatile manner. The spinneret and associated glands are of vital importance to aquatic nemas; and this apparatus is all but universal among them. The three elongated ellipsoidal *caudal glands*, 84, 88, 90,—the remotest of them ten body-diameters in front of the anus,—are scattered in a loose tandem in the ventral part of the body cavity. Their ducts, 18, 86, leading to the spinneret, can be distinctly seen under some circumstances. Most of the caudal setae on the female are reduced and inconspicuous

It is the sticky nature of the secretion of the caudal glands that enables these nemas to ensconce themselves so securely in the midst of the elements of the mud in which they live By its aid they attach themselves to the substratum, especially in times of danger, and to each other By means of this cement, they bind themselves together with mud etc in almost inextricable tangles.

The two very thin ribbon-like lateral cords, 3, 93, of *Metoncholaimus pristiurus*, one on each side, immediately under the cuticle, are about half as wide as the body, each cord consisting of three regions,—a median region composed of a single broad row of quadrate cells, and a row, less than half as wide, on each side of it. In the anterior part of the body the quadrate cells are usually a little longer than they are broad, in the posterior part a little shorter than broad. As stated, these median cells are flanked by two much narrower longitudinal series of cells, having the same general composition, i e a very fine protoplasmic network (meshes two microns to five microns) in the intersections of which are roundish or somewhat ellipsoidal yellowish granules, usually not equidiametral. Even without staining, there are also to be seen, at least in each of the cells composing the central row of the lateral cord, faint indications of a nucleus, these indications in the living nema consist in an almost entire absence of the reticulation which is to be found elsewhere in the cell These cells of the lateral cord are necessarily very flat; that is to say, their depth (radially to the nema) is much less than their diameter in either of the other two directions,—i e longitudinally to the nema or tangentially. The division line between the central row of cells and the narrower ones on the margin is an almost invisible, very thin, somewhat indirect cell-wall line. Around the outer margins of the two outer rows of cells the granules are slightly *differentiated* from the other granules; so that in

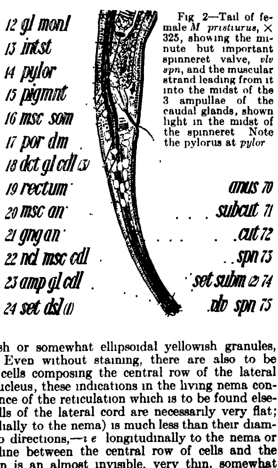

Fig 2—Tail of female *M pristiurus*, × 325, showing the minute but important spinneret valve, *vlv spn*, and the muscular strand leading from it into the midst of the 3 ampullae of the caudal glands, shown light in the midst of the spinneret Note the pylorus at *pylor*

seawater-methylene-blue the subcuticular pigment granules on the *borders of the longitudinal bands*, already described in connection with the *cuticle*, may stain green at a time when the rest of the granules stain blue. This appearance is similar to what is now being described for the unstained nema; so that the structure of the lateral cords is now shown to be in harmony with that of the longitudinal bands of subcuticular pigment. In other words, the arrangement of the pigment granules of the cuticle is doubtless in some way correlated with the arrangement of the cells in the lateral cords beneath. The protoplasmic network in the cells of the lateral cords is considerably finer than the protoplasmic network in the outer part of the cells composing the intestine, but nevertheless, has the same general appearance. The lacunae among the strands of the network are of variable size, more or less equidiametral, though never exactly so,—polygonal, but not regularly so The lateral cords are wellsprings of the cuticle

The granules of the subcuticle, 34, 82, 95, differ from the yellowish granules contained in the network of the cells of the lateral cord, in the specimen under examination the granules in the subcuticle (a little under one micron) are more nearly colorless and are round, whereas those in the lateral cord are yellowish, and somewhat irregular in size and form.

Renette and excretory pore The excretory pore, 58, is located about one-fourth the distance to the nerve-ring on the ventral side of the neck The *nucleated single renette cell*, 68, about four body-widths behind the neck, is a fusiform, granular, ventrad cell, about twice as long as wide, and nearly two-thirds as long as the corresponding body diameter, the *renette duct*, 60, 67, leads from it, somewhat meanderingly, forward to the excretory pore, and is readily seen, as a rule,—or at least some of it is It is a slender tube about one-twentieth as wide as the neck and ends anteriorly in a small ellipsoidal *ampulla*, near 58, nearly one-third as long as the neck is wide, emptying outward through the ventral *excretory pore* in the cuticle by means of an exceedingly narrow duct only three to four microns long. The excretory secretion of this gland, as seen in its duct, and ampulla, is granular, the uniform, spherical, colorless granules being about one micron in diameter. This entire apparatus, the *renette*, is regarded as excretory in function

Nervous system. An important part of the central nervous system is the *nerve-ring*, 38, about ten microns wide, surrounding the oesophagus somewhat obliquely in front of the middle It consists of a compact network, or skein, of exceedingly fine nerve fibers Before and behind the nerve-ring are scores of distinct nucleated *ganglion cells*, 11, 56, *etc*, mostly bipolar, those in front being arranged in eight obscure longitudinal groups,—two lateral, one ventral, one dorsal, and four submedian. The ganglion cells are variously connected with each other and with the nerve-ring Placing the nema over night in seawater-methylene-blue discloses some of the elements of the *ventral nerve* leading from the nerve-ring along the ventral line to the tail Usually about 128 fusiform elements in the ventral series may be disclosed (stained blue) in this way These can be proved to be connected with each other The same treatment is likely also to reveal the nerve elements entering the bases of setae, and papillae, especially in the tail of the male. See Fig. 4.

Female organs From the slightly elevated *vulva*, 7, which is a transverse ventral slit of moderate size, the medium sized *vagina* leads inward and slightly forward about halfway across the body; the vagina is somewhat cuticularized and is accompanied by small and very inconspicuous *vaginal glands*, 9, fore and aft. About two dozen *radiating muscles*, 6, occur around the

vulva, together with an associated complicated nerve plexus This musculature is least developed behind the vulva.

The straight *uterus*, 30, 8, extends forward, and is of such capacity as to accommodate a maximum of about forty *eggs*, 10, 39, (i e , many more than shown in this drawing) arranged approximately single file,—although this large number of eggs is rarely seen except toward autumn Under such circumstances the oblate eggs, seeming to nearly fill the body cavity in this region, are more or less ellipsoidal in contour and half a body-width long, and twice as wide as long When deposited, or when not crowded in the uterus, the eggs are ellipsoidal and longer than wide The *shells* of the eggs, one and a half microns thick, are smooth, and the eggs are deposited *before segmentation* begins. Naturally, the length of the uterus varies according to the number of eggs it contains.

The broad *reflexed ovary* appears more or less cylindroid, and when there are, say, a dozen eggs in the uterus, the terminus of the ovary, 59, lies about halfway back to the vulva The narrow *oviduct*, 46, 52, leading from the front end of the ovary back to the uterus, is usually nearly invisible, but when a ripe ovum, 50, having passed round the bend (flexure) near 46, is being forced backward through it from the front part of the ovary back to the uterus, its presence is obvious It is faintly visible at 52. The ova are fertilized on first reaching the uterus, and soon after this it is not very uncommon to witness the early stages of the formation (*mit*, Fig 1) of the *polar bodies*,—which appear later as small spherical bodies just under the eggshell A small collection of sperms is seen in the spermathecal region at 61.

The demanian system In the adult female of *Metoncholaimus pristiurus* there is a complicated double *system of efferent tubes*, the *demanian vessels*, connecting, first, with the posterior part of the intestine through an *osmosium*, 87, and second, with the posterior end of the uterus by means of a very long slender efferent duct, 79, 85 These two efferents join at a conspicuous thirty-two-merous, special glandular gateway,—the *uvette*, 40,—and empty, by way of the *uvette* pore, 62, thence backward and outward through two separate narrow lateral ducts, 42, having attached to them, *along their outer sides*, relatively large and long conspicuous *moniliform affluent glands*, 64, seventeen microns wide, each consisting usually of sixy-four somewhat discoid elements, 66,—occasionally double (?) this number These discoid cells of the two moniliform glands are three microns thick and packed with granules of the order of one micron; the flat ducts, along the inside of the moniliform glands, lead to two *exit pores*, the right hand one shown at 17, five by seven microns, laterad in the body wall one-half tail-length in front of the anus However, the caudad elements of the moniliform glands are "pyriform," as shown in the illustration,—not discoid The demanian vessels elaborate a *copious, elastic, sticky, non-water-soluble, nearly colorless secretion*, possibly utilized during agglomeration and copulation, and also mayhap to protect and preserve the batches of eggs after deposition and during segmentation.

The uvette, 40, is a very striking organ consisting of thirty-two concentrically arranged, highly refractive, flask-shaped, glandular elements, all concentric about a single *minute central pore*, 62, leading into the large duct passing backward and dividing to form the two lateral efferent ducts each accompanied by a sixty-four-fold moniliform gland, as already described. The connection of the intestine with the demanian system at the osmosium is *not an open* one; the nature of the connection with the uterus, however, appears less certain

The osmosium, 87, of the enteric efferent is located about one-third the distance from the anus to the vulva, and may usually be seen on the dorsal side of the intestine,—being mainly visible on account of the somewhat greater transparency of its tissues. The narrow uterine efferent duct, *ut. eff.*, 79, 85, is very difficult to follow throughout its length, and usually can be seen only in specially favorable specimens. Its connection with the posterior end of the uterus is sometimes easy to see,—near 30. Its connection with the uvette is also nearly always easy to see, and it may be followed thence forward a short distance, but to trace it far is usually a matter of some difficulty.

The thirty-two flask-shaped elements of the uvette have their *necks* concentrated at the pore. The wall of the uterine duct, as previously described, spreads out over the uvette, and beneath it the thirty-two elements form a craterlike affair leading to the uvette pore. This pore opens into the somewhat duplex (but really monoluminal) corridor of the caudad part of the intestinal efferent. This latter efferent may show signs of forking at a distance in front of the uvette about equal to the corresponding body diameter, but is seldom, if ever, really bifurcate until behind the uvette.

Or,—following the demanian system from the rear toward the uvette:—Where the moniliform glands approach the uvette, they join to form a two-fold structure, and the pore of the uvette is placed between the two parts of this double structure. The structure of the *tunic* of the demanian system opposite the uvette presents two sets of exceedingly fine symmetrically arranged elements,—one sloping 45° right, the other left,—which continue forward. This "spiral" structure can be seen throughout the duplex portion of the demanian system now being described, namely that portion in the vicinity of the uvette

Sperms, 61, are to be seen at the cephalad end of the uterus *i.e.*, the *spermatheca*, where the oviduct joins the uterus, sometimes in a mass comprising scores of sperms, each about one-tenth as wide as the corresponding portion of the body. They are rather difficult to see except when they are present in considerable numbers.

MALE. Fig 3

The spicula and other male organs $\frac{0.8}{0.8}, \frac{8.5}{1.2} \frac{11.}{1.3} \frac{82\ M}{1.5} \frac{96.}{0.7}$ 5.8 mm

The tail of the male is more or less like that of the female in form, but is somewhat larger, more arcuate, and *far more flexible*, even prehensile, as Fig. 2 indicates It diminishes a little more suddenly in size at the anus, and is armed with special setae and papillae. The two, equal, colorless, long and very slender, uniform *spicula*, 57, 58, seven times as long as the anal body diameter, are almost imperceptibly cephalated by expansion. They are simple and frail looking, their proximal ends lying more or less opposite the body axis A long slender, duplex, nucleated *retractor muscle*, 16, extends forward from the proximal end of each spiculum to the body-wall in the corresponding subdorsal region, near 12; an antagonistic *protrusor muscle*, of about equal size *ensheaths* each spiculum. The small *inconspicuous gubernaculum*, 42, lying near the anus, is *double* and straight. Its two equal parts are somewhat frail and simple, but are expanded internally so as to be visible. They are only about half as long as the anal body diameter, and lie against the tips of the spicula in such a way that their swollen and more visible proximal ends, 42, lie nearly opposite the axis of the base of the tail.

There is a single inconspicuous *preanal ventral papilla*, 22, very close to the anus, 21, but readily seen when searched for. There are about ten small

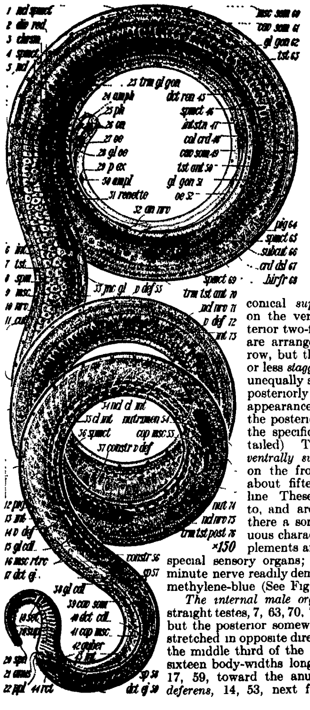

Fig 3—♂ *M pristiurus*, from balsam specimens; stain, acid carmen Compare with Fig 1 Here the nuclei are brought out more distinctly The renette and caudal glands may be followed throughout Development of the sperms can be followed; reduction division is shown at 2 The long gland accessory to the male gonads can be followed from 23 to 33 One of the exceedingly slender spicula is shown, together with its long duplex, nucleated retractor muscle The oblique copulatory muscles of the male extend forward to near the vicinity of 74 The minute but important spinneret valve is shown at 20 The oesophageal glands shown at 28, may be profitably compared with the larger drawings in Fig 1

conical *supplementary organs*, 19, on the ventral and subventral posterior two-fifths of the tail. These are arranged in a sort of ventral row, but the anterior ones are more or less *staggered*; they are somewhat unequally spaced, being wider apart posteriorly They give a serrated appearance to the ventral contour of the posterior part of the tail, hence the specific name, *pristiurus* (saw-tailed) There are also about thirty *ventrally submedian short setae*, 18, on the front portion of the tail, about fifteen on each subventral line These two rows extend forward to, and around, the anus, forming there a sort of circlet of inconspicuous character. These conical supplements and setae of the male are special sensory organs; each is supplied with a minute nerve readily demonstrable with seawater-methylene-blue (See Fig 4).

The internal male organs. The two slender, straight testes, 7, 63, 70, 76, of about equal length, but the posterior somewhat the longer, are outstretched in opposite directions, and extend along the middle third of the body, each being about sixteen body-widths long. The *ejaculatory duct*, 17, 59, toward the anus, is one-fifth; the *vas deferens*, 14, 53, next farther forward and set

off from the ejaculatory duct by a distinct constriction, 56, is one-fourth; and the testes average one-fourth to one-half;—as wide as the body. There is a constriction midway in the *vas deferens*, 37. The blind end of the *anterior testis*, 70, directed forward, is about two neck lengths behind the cardia, while the blind end of the *posterior testis*, 76, directed backward, is about five tail-lengths in front of the anus

Beginning between the renette cell and the cardia (at 23) there is a long, straight, tapering *accessory gland*, 51, emptying backward into the beginning of the *vas deferens*, i.e., at the point where the two testes join it, 33 This gland, accessory to the gonads, is, no doubt, a reduced homologue of the demanian system of the female A possible function is the production of cement (aseptic?) used in copulation

The primary *spermatocytes*, 69, near the blind end of the testes are about forty microns in diameter About twenty of them would be required to span the corresponding body diameter *Full grown spermatocytes*, 4, 36, occur farther along the testes in rouleaux, and are two-fifths as wide as the body of the nema and one-third as long as wide Nearly simultaneous *synapses* and *reduction divisions* of a full grown sperm are often in progress in one or the other testis, 2, 3, and the members of the resulting *quartet*, 2, of smaller cells,—that is the resulting spermatids,—are somewhat equidiametral and are about one-fifth as wide as the body

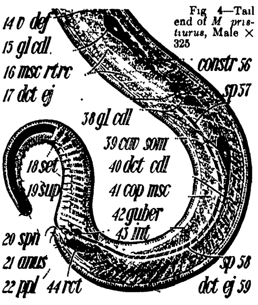

Fig 4—Tail end of *M pristiurus*, Male × 325

The three caudal glands, 15, 38, and their three ducts, as at 40, are shown more clearly when stained, as in the male specimen figured

Habitat Stagnant marine mud, below low tide, often where there is a slight overgrowth of eelgrass, harbor at Woods Hole, Massachusetts, U. S A. at all seasons It also occurs in the Mediterranean Sea, near Naples, Italy This species is subject to autumnal (?) attacks of fungi and bacteria. The resulting diseases are of a very interesting character, and sometimes give rise to necrosis of the posterior part of the body One of the common assailant cyanophytes(?) gives rise to an extensive aigrette-like appearance

Examination of the living specimens may very profitably be supplemented by examination of temporary mounts in lactophenol, 5 per cent solution of potassium hydrate, and (broken open) in acetic acid-methylene green, as well as "intra-vitam" in seawater-methyl blue

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1029TH MEETING

The 1029th meeting, constituting the 61st annual meeting, was held in the Cosmos Club Auditorium, December 7, 1931, President CURTIS presiding

The treasurer reported expenditures of $1353 03 for the year, and stated that the active membership of the society is 240.

The secretaries reported that the following new members were elected during the year: A. V ASTIN, L E BARBROW, H. F BENNETT, C. BITTINGER, A. BLAKE, H. E. BURTON, L. F CURTISS, F. T. DAVIES, I. A. DENISON, S. EWING, I HARTMANN, H D HUBBARD, F E. JOHNSTON, A G MCNISH, W. R. OSGOOD, B. L. PAGE, M. F PETERS, J. D. PHOENIX, W RAMBERG, H F. SCHIEFER, G. B. SCHUBAUER, J SMALL, P. SOLLENBERGER, W. T SWEENEY, R. P TEELE, M. J. WEST, R C WHEELER and J. E WILLIS

O. H TITTMAN was transferred to life membership

The following deaths were reported: F. W. CLARKE, A J HENRY, H L. HODGKINS, F. G TINGLEY.

During the year the first Joseph Henry lecture in memory of the first President of the Philosophical Society was given by JOSEPH S AMES, President of Johns Hopkins University

The following officers were declared elected for the year 1932: *President*, L. B TUCKERMAN; *Vice Presidents*, O S ADAMS and H. L. DRYDEN, *Corresponding Secretary*, F. WENNER; *Treasurer*, E. W. WOOLARD, *Members-at-large of the General Committee*, N H HECK and E O HULBURT

At the conclusion of the business meeting, E C CRITTENDEN read a paper on *The Faraday Centenary Celebration in Great Britain* —The Faraday celebration held in Great Britain September 21 to 25 was intended primarily to mark the hundredth anniversary of the discovery of electromagnetic induction. Faraday's diary shows that on August 29, 1831, he observed a transient electric current in a coil wound on one-half of a ring of iron, when a current was started or interrupted in another coil wound on the other half of the ring. During the next few months he carried out and recorded a series of experiments which established the basic principles governing the creation of an electromotive force in a circuit by changing the magnetic flux through that circuit. The diary and much of Faraday's original apparatus was preserved at the Royal Institution where this work was done

The Centenary Celebration was organized jointly by the Royal Institution and the Institution of Electrical Engineers. It was one of a series of affairs which filled the whole month of September The series included an International Illumination Congress, a session of the International Commission on Illumination, the summer meeting of the Institution of Electrical Engineers and the centenary meeting of the British Association for the Advancement of Science.

The celebration itself included a number of receptions or "conversaziones," dinners and excursions, but the outstanding features of scientific interest were, first, a lecture by Sir William Bragg in which several of Faraday's experiments were repeated with the original apparatus, and, second a very elaborate exhibition illustrating many branches of Faraday's experimental work and the industrial developments which have grown more or less directly out of them. (*Author's abstract*)

Discussed by Messrs. MYERS and LITTLEHALES.

G. R. WAIT, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

The degree of doctor of science has been awarded to Dr. LYMAN JAMES BRIGGS, assistant director of the Bureau of Standards, by his *alma mater*, Michigan State College

At the recent annual convention of the American Malacological Union held in Washington, Dr. PAUL BARTSCH of the National Museum was elected to the presidency of the union

The Hillebrand prize of the Washington section of the American Chemical Society has been awarded to Dr. G. E. F. LUNDELL of the Bureau of Standards in recognition of the outstanding merit of his book on analytical chemistry.

Obituary

Dr. NATHAN AUGUSTUS COBB, former president of the Academy, died suddenly in Baltimore on June 4, 1932, at the age of 72. Dr Cobb was an authority on nemas, and a paper on this subject prepared shortly before his death appears in this issue of the Journal

Born in Spencer, Mass, Dr Cobb was educated at Worcester Polytechnic Institute and at the University of Jena in Germany, where he took honors under Haeckel, Hertwig, Lang, and Stahl After obtaining his Ph.D degree, he returned to teach for nine years in Massachusetts schools. He was then appointed by the British Association for the Advancement of Science to conduct work at its Naples zoological station, where he remained for two years He then went to New South Wales, where he served in various capacities in the department of agriculture in that country for thirteen years After three years in Hawaii, Dr Cobb came to Washington to join the U. S. Department of Agriculture, becoming acting assistant chief of the Bureau of Plant Industry in 1911

Dr Cobb discovered and described about 1000 new species of animals and plants and was the author of 200 pamphlets and books He was a member of the Washington Academy of Sciences, Helminthological Society of Washington, Botanical Society of Washington, American Society of Parasitologists, American Microscopical Society, American Association for the Advancement of Science, Medical Congress of Australia, Hawaiian Entomological Society, Australian Association for the Advancement of Science, and the New South Wales Linnean Society.

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GEOLOGY.—*Stratigraphy and structure of Northwestern Vermont.*—I.[1]

ARTHUR KEITH, U. S. Geological Survey.

GENERAL GEOGRAPHY AND GEOLOGY

The historic region described in this paper is the north end of the Appalachian Valley in the United States. This part of the Valley is called the Champlain Valley and lies partly in New York and partly in New England. In the largest view it is bounded on the east by the Green Mountains and on the west by the Adirondack Mountains, and at the south it is split by a minor group of mountains—the Taconic Range. A large part of the Valley is occupied by Lake Champlain, the surface of which is 100 feet above sea level. The bottom is below sea level. The Valley passes northward into Canada and curves northeastward, merging into the St. Lawrence Valley.

The Champlain Valley is 20 miles wide at the latitude of Burlington and extends southward for 80 miles from the Canadian border to the Taconic Range. The Valley is there divided by the Range into two parts; the western one, which is continuous into the Hudson Valley of New York, and the eastern part, which extends as the Western Valley of New England nearly to Long Island Sound This part of the Valley also has several names for individual sections, such as Rutland Valley, in Vermont, and Stockbridge Valley, in Massachusetts. The eastern side of the Champlain Valley is sharply marked by the abrupt rise of the Green Mountain front, which trends nearly north and south and is close to the east side of the six quadrangles herein described. The western side of the Valley is also clearly marked by the bold slopes of the Adirondack Mountains in New York. Near the south end of Lake Champlain these mountains come to the shore of the Lake.

[1] Received June 6, 1932 Published with the permission of the Director, U S Geological Survey

STRATIGRAPHY

The Valley and its southern branches are floored by Paleozoic limestone, dolomite, marble, shale, and slate with a few belts of quartzite. All of these rocks except the quartzite are rather easily eroded and their surface is well worn down toward sea level. They range from Lower Cambrian age to Middle Ordovician, the older formations showing mainly in the eastern part of the Valley and the younger ones in the western part The west half of the Valley and its extension southward into the Hudson Valley is floored mainly by a few formations of Ordovician shale and limestone, while the east half is underlain by many formations of Cambrian limestone, dolomite, marble, and quartzite. These two groups are separated by the Champlain overthrust. The latter formations also underlie nearly all of the Western Valley of New England. Thus, in a broad way, older and older rocks appear as one travels from west to east As a result of this general progression, the eastern margin of the Valley and the front of the Green Mountains are formed by the lowest Cambrian quartzites, and by still lower formations of the Algonkian. In the heart of the Green Mountains still lower formations appear in the granites and gneisses of the Archean.

A marked departure from this plan is seen in the Taconic Range. There, the carbonate rocks which characterize the Valley disappear and nearly all the formations are of slate. One thin quartzite formation is present and one very thin limestone formation, which together form perhaps 5 per cent of the total section. There is one slate formation of Middle Ordovician age, two of Lower Ordovician age, and seven of Lower Cambrian age. No Middle or Upper Cambrian is present. The Lower Cambrian of the Taconic Range lies on or beside the Lower Cambrian of the valleys, and the two groups have no features in common except that of age. This is expressed by nature in the fact that one group makes mountains, while the other forms the valleys. Similarly, most of the Ordovician formations of the Taconic Range differ widely from the Ordovician of the surrounding valleys.

Other discrepancies of this sort are found in the Champlain Valley, so that in all one finds three major tracts in the Valley, a fourth in the Taconic Range, and a fifth in the Green Mountains, which differ strikingly from one another in the formations present and in their metamorphic condition. Each of these natural groups is called a sequence and each is separated from the others by a major fault, as shown in Fig. 1. These sequences are called Western, Central, Eastern, Taconic, and Green Mountain sequences in order to show where they are best developed. The Champlain overthrust separates the

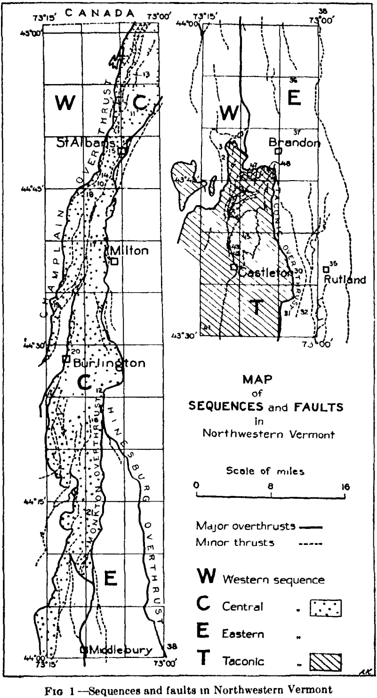

FIG 1 —Sequences and faults in Northwestern Vermont

TABLE 1 —CORRELATION TABLE FOR CHAMPLAIN VALLEY AND NORTHERN TACONIC RANGE ARTHUR KEITH 1932

	WESTERN SEQUENCE		CENTRAL SEQUENCE		EASTERN SEQUENCE	TACONIC SEQUENCE	GREEN MTS SEQUENCE
	Eastern N Y	Sudbury region	St Albans region	Burlington region	Brandon-Rutland region	Taconic Range	Central Green Mountains
	Snake Hill formation*	1 Hortonville slate					
	Glens Falls limestone*	2 Hyde Manor limestone*	erosion			erosion	
	Black River limestone*				erosion	Black slate*	Randolph phyllite
O	Chazy limestone*	3 Sudbury marble	erosion		30 West Rutland marble*	Indian River slate	Waits River limestone*
	Beekmantown limestone*	Beekmantown limestone	10 Georgia slate*	erosion	unconformity 31 Ira slate	41 Poultney slate*	Memphremagog slate*
			11 Corliss conglomerate*	Corliss conglomerate			
	Little Falls dolomite		unconformity	12 Williston* limestone	Williston limestone		
UC	Hoyt limestone member at top Theresa dolomite		13 Highgate slate*	Highgate slate			
	Potsdam sandstone		14 Mill River* conglomerate				

MC	Unconformity	unconformity 15 St Albans slate*	hiatus	hiatus		
			16 Shelburne marble	Shelburne marble		
		unconformity 17 Milton dolomite	Milton dolomite	32 Clarendon Sprgs dolomite	hiatus	fault
		unconformity 18 Parker slate	Parker slate		42 Hooker slate	Ottauquechee phyllite of Perry
LC		19 Mallett dolomite*	Mallett dolomite	Wallingford dolomite*	43 Beebe ls *	
					44 Bull slate	
					45 Barker qtz	—quartzite
		20 Winooski marble*	Winooski marble	Danby formation	46 Hubbardton slate	Pinney Hollow schist of Perry
					47 Stiles phyll	
		21 Monkton quartzite*	Monkton quartzite*		48 Brezee phyllite	Albite schist
		fault	fault	35 Rutland dolomite	fault	Plymouth marble
				Cheshire quartzite		Cheshire quartzite

TABLE 1.—CORRELATION TABLE FOR CHAMPLAIN VALLEY AND NORTHERN TACONIC RANGE. ARTHUR KEITH, 1932—*Concluded*

	WESTERN SEQUENCE		CENTRAL SEQUENCE		EASTERN SEQUENCE	TACONIC SEQUENCE	GREEN MTS SEQUENCE
	Eastern N Y	Sudbury region	St Albans region	Burlington region	Brandon-Rutland region	Taconic Range	Central Green Mountains
AL					unconformity 36 Moosalamoo phyllite		unconformity
					37 Forestdale marble		
					38 Nickwaket graywacke		unconformity Nickwaket graywacke
AR	Granite and gneiss				granite and gneiss		granite and gneiss

Fossil horizons shown by * Formation type localities in this area are numbered and shown on map

Western from the Central sequence, the Monkton overthrust is the boundary between the Central and Eastern sequences, and the Taconic overthrust separates the Taconic sequence from the others There are eight principal Paleozoic formations in the Western sequence, twelve in the Central sequence; nine in the Eastern sequence; and ten in the Taconic sequence. The mutual relations of these are shown in the correlation chart (Table 1) Many of these formations can be subdivided into members, especially in the Western Sequence where fossils are numerous.

STRUCTURE

The geologic structures of the Champlain Valley exhibit the features which are usually found in the Appalachian Valley, consisting of long, narrow folds overturned toward the northwest and split by numerous faults Other faults (the great overthrusts) mentioned above are more than usually numerous, and bringing the extremes of sedimentation together they greatly complicate the structure of the region. The rock formations have the same north-south trend as the structures except here and there where they are shoved aside by the great overthrusts.

Because of differences between the various formations in respect to ease of erosion, the Valley is very plainly defined from the Mountains, and the weaker formations of the Valley are separated by the minor ridges of the harder formations, like the Monkton Hills No attempt will now be made to discuss the various stages of erosion and uplift by which the surface has attained its present forms. These differ only in place but not in kind from those of other New England States Those of Massachusetts have been described by the writer elsewhere. No space will now be given to the glacial history of the region with its tilting, erosion, and blanketing of the bed rock Attention will be directed solely to structures in which the rocks have been changed in form, attitude, or composition, and the relation of these structures to the nature of the rocks involved will be briefly analyzed

This region is at one of the great salients of the Appalachian system where the rocks of the earth's crust have been pushed farther forward toward the west than in adjoining regions. The axis of the salient crosses the Valley and Mountains in the St. Albans district, where the structures change trend from northerly to northeasterly Further south—in the Rutland district—the folds have lagged behind those of the St. Albans district and even trend to the west of north. This is

the only place in the Appalachian system where such a general trend is seen. The lag is due to the massive buttress of the pre-Cambrian rocks in the Adirondack Mountains, which checked the westward advance of the folds.

The rocks of this region show the results of extreme compression and exhibit a great variety of folds, faults, and metamorphism. First came the group of great overthrusts, the Champlain being earliest, followed by the Monkton and Hinesburg thrusts, with the Taconic as a climax Doubtless a moderate amount of folding took place at this time, but it cannot be separated from later folding. Each of these overthrusts was marked by much horizontal movement, but the Taconic overthrust was far greater than the others. Its roots lie far to the east in the Green Mountains, nearly 20 miles away. The Taconic overthrust mass was forced completely over the other thrust masses and is now to be seen overriding two of them, the Monkton and the Champlain, at the north end of the Taconic Range. On each overthrust there were brought together groups of formations of the same age but of very different nature and formed originally many miles apart.

Apparently the overthrusting reached a deadlock, being stopped by friction and piling up of the masses. The pressure was still being applied, however, and the rocks were still more folded and masked. With them were folded the overthrust planes and masses until in places they were turned upside down, as along the east side of the Taconic Range. Still further compression split many folds and formed minor thrusts and faults Some of these, for instance the Castleton fault, would in any other region be considered large, and they were able to slice through the great overthrust masses and dislocate them into separate blocks Such results are well seen in the vicinity of Burlington and Middlebury, where the Champlain overthrust was dislocated. A far finer example of this secondary dislocation is seen in the northern part of the Taconic Range, where a dozen secondary thrust faults have cut the overthrust mass into slices This is by far the best exhibition of such structures yet found in the Appalachians or perhaps in North America

The process of compression went on until in some sections—notably near St. Albans—scarcely a vestige of folding remains, all being swallowed up in a succession of slices. The planes of the great overthrusts dipped originally at low angles toward the east, they still do so in some places, though they are overturned in others The lesser faults dip as a rule less than 45 degrees to the east

In many places the overthrust masses were raised so high on the secondary structures that erosion has revealed the underlying rocks in fensters. The largest of these appears a few miles west of Middlebury and east of Snake Mountain, where the limestones of the Western sequence are exposed in a tract covering many square miles This is indicated in Fig. 1. Smaller structures of the same sort are found in the vicinity of Burlington on the same overthrust which is there close to the water front. Of the same nature, but enormously greater in scale, is the structure of the region east of the Taconic Range and including the western part of the Green Mountains. All of this was brought above the erosion plane by folding and faulting subsequent to the Taconic overthrust. The outcrop of this overthrust now forms an enormous flattened Z, the middle line of which reaches from the north end of the Taconic Range into Massachusetts, where it turns back to the northeast

A far different arrangement is seen west of the Champlain overthrust, where the Western sequence of formations prevails Folding is at a minimum and is expressed mainly by tilting at angles which seldom are as great as 30 degrees The tilting was mainly accomplished by normal faults which trend in a great variety of directions and of which the throw is commonly small A very few faults of this kind are known to cross the Champlain overthrust into the region of the Central sequence. It is possible that more will be found but probably not many. The rocks of this sequence exhibit practically no metamorphism except some slaty cleavage near the Champlain overthrust, and the whole system of structures differs so widely from those on the east side of the Champlain fault that they obviously belong in different provinces.

Hand in hand with the movements of folding and faulting there was deformation by metamorphism. This was least in the Western sequence so that shales were barely transformed into slates and fossils were scarcely deformed. At the east, however, the changes were extreme, no rocks escaped entirely and some were mashed almost beyond recognition. Granites were mashed to schists in places, and interbedded quartzites and shales were dissected until they resemble augen gneiss Interbedded limestones and dolomites were transformed into strings of blocks of ruptured dolomite, between which was forced calcite marble. Such metamorphism was accomplished not only by physical rupture and separation but by chemical recrystallization. The details of this differ widely between marbles, slates, quartzites, graywackes, and granites. The differences in aspect produced by these chemical changes are greatest in rocks which originally

contained alumina in the form of clay or feldspar. In such rocks the development of micas proceeded to great lengths, so that new structure planes—schistosity—were produced in them, and rocks of different original composition approach each other closely in appearance. In these rocks lithologic composition is of little value in fixing their ages, and phyllites of Ordovician and Algonkian ages may be identical in appearance.

Between the extremes of metamorphism there are many intermediate grades The western margin of readily noticeable metamorphism is not far west of the Taconic overthrust at the south, and of the Champlain overthrust at the north The metamorphism is substantially limited to the region covered by overthrusts and doubtless is due to the combination of intense lateral pressure with the greatly added overburden of the overthrust mass. It is because of this intense recrystallization of the limestone and dolomite, and the changes of bulk, color, and pattern that went with it, that this region has the largest body of fine marble in the United States.

INDIVIDUAL FORMATIONS

The general character of the formations exhibited in this region has been mentioned briefly in the foregoing general descriptions. The formations are described according to sequences, all of the formations in one sequence being treated before considering those of another sequence. Each of the sequences, and of the formations contained therein, is shown in the correlation table The first sequence described is the western one and the others are described in the order from north to south. On the map and in the correlation table numbers show all of the formation type localities that are in this region.

The outcrops of rock are very good in some parts of the district, such as the northern part of the Taconic Range and the upper slopes of the hills and ridges throughout the region All of the ledges have been scraped and polished by the Pleistocene glaciers, and the decomposed rock has almost everywhere been removed. On the other hand, exposures are very poor in the low ground, most of them being covered by glacial drift The lower levels of the Valley are usually filled with glacial clay deposited in the glacial lakes at various stages. This clay conceals everything for great areas near Lake Champlain. In the eastern and higher tracts there are numerous sand plains and terraces ranging from 200 to 1,600 feet in altitude. These are particularly clustered around the points where the rivers come out of the mountains, and they cover all kinds of the bed rock, so that in places it is

impossible to tell precisely how the formations connect from side to side of a delta. In the Green Mountains boulder clay conceals most of the rock, which only here and there projects through it or is uncovered by the down-cutting streams. On one kind of glacial deposit or another it is possible to travel many miles continuously without any rock exposures whatever. This drift blanket is most oppressive in the country near and north of St Albans, where stratigraphic changes are numerous and thrust faults are very common In tracing the formations, however, much help is obtained from the characteristic topography of each formation.

WESTERN SEQUENCE

The sedimentary rocks of this sequence begin with the Upper Cambrian and rest directly upon the Archean granite and gneiss A detailed description of these formations is not given here because the writer's field work has been mainly directed to the highly disturbed rocks of the other sequences Some knowledge of them is needed, however, as a setting for the geology east of the Champlain overthrust.

The first Paleozoic deposit of this sequence is the Potsdam sandstone. This is found in many belts around the Adirondack Mountains and usually makes prominent ridges or mountains On the east side of the Adirondacks this formation is a quartzite with a basal conglomerate and closely resembles the Lower Cambrian Cheshire quartzite of the Eastern sequence

The Potsdam is believed to be of Upper Cambrian age but has so far yielded no fossils There is a zone of interbedded quartzite and dolomite between the Potsdam and the overlying Theresa dolomite of Upper Cambrian age, which is in favor of an Upper Cambrian age for the Potsdam beds The Potsdam is included in Ulrich's Ozarkian system, together with the Theresa and Little Falls dolomites

The Theresa dolomite is a gray massive dolomite with many interbedded layers of sandstone, particularly at the base as already noted. The formation contains trilobites which establish its age Above the dolomite, but included with the formation as a member, is the Hoyt limestone This also contains beds of gray dolomite and oolite, and numerous fossils.

The Little Falls dolomite is similar to the Theresa dolomite in lithologic appearance and also has very few fossils. Nodules of black chert are found in this dolomite and also a remarkable development of cryptozoon reefs

The first beds of the Ordovician are those of the Beekmantown limestone. All of the divisions of the Beekmantown are found in the

towns of Orwell and Shoreham, immediately northwest of the end of the Taconic Range. The formation consists chiefly of limestone with numerous beds of dolomite. Fossils are very numerous in some parts of the formation, and there are many peculiarities in the lithology in the limestone layers. Most of the limestones have a bluish color whereas the dolomites are light or dark gray. Some of these beds are seen along the Champlain overthrust west and northwest of St. Albans.

The Chazy limestone, which follows the Beekmantown, is also composed mainly of bluish limestone and fine gray dolomite. The dolomite also has lighter colored layers and some which weather with peculiar chamois-colored surfaces. The formation carries many fossils which serve to distinguish it from the Beekmantown There is some uncertainty about the age of some dove-colored limestones which have been assigned both to the Chazy and to the Beekmantown

The Sudbury marble, which outcrops in the town of Sudbury at the northwest end of the Taconic Range, appears to be of Chazy age, although it has no fossils It rests upon the Beekmantown and it underlies limestone of Trenton age, being only separated from the latter by a heavy bed of gray dolomite. The marble is, for the most part, snow white but contains also a few cream colored beds of fine dolomite It is possible that these three formations belong in the Central sequence instead of the Western, but this is still in doubt on account of the prevalence of thrust faults in that district.

The Trenton, which normally follows the Black River, is best developed in Western New York In the Schuylerville region of New York, which joins this region on the southwest, the Trenton is possibly represented by the upper part of the Normanskill shale which includes at the top the Ryesdorph conglomerate member, and also by the Snake Hill formation. The greater part of the Normanskill shale is regarded as of Chazy age All of these shales are gray or dark, with interbedded layers of sandstone and cherty slate, and contain fossils, chiefly graptolites

The Hyde Manor limestone, occurring near the north end of the Taconic Range, contains a good brachiopod fauna of Trenton age, entirely different in aspect from that of the shales of the same age at the west and southwest. This limestone has a decided blue color and consists of massive beds interlayered with thin slabby strata. Considerable schistosity is evident in this limestone and it is strongly folded, which facts support an assignment of the formation to the Central sequence. Fossils are rather common, however, which tends in an opposite direction toward the Western sequence.

Lying above the Hyde Manor limestone is the Hortonville slate, a dark or black slate with portions which are sufficiently altered to be called phyllite There are also in the slate a few small seams of siliceous material giving a local banded appearance As a rule the bedding is obscured by the cleavage. This is well exposed around Hortonville, Vt , and, though unfossiliferous, is correlated with the Snake Hill formation of New York.

CENTRAL SEQUENCE

The Central sequence is exhibited in two general areas, as shown on the correlation chart The lower half of the column is the same for each area, but the upper half differs materially Some differences are due to unconformity and overlap which produced Middle and Upper Cambrian beds found only in the St. Albans region. Also, in the St. Albans region there are two Ordovician formations which doubtless have been eroded from the Burlington region, owing to the greater depth of erosion there The section passes from a quartzite at the base through dolomites and marbles and into slates at the top

Monkton quartzite — The sequence begins with the Monkton quartzite, of Lower Cambrian age This is seen in Burlington in quarries and natural exposures, and is one of the best key rocks of the region. The original thickness of this formation is not known nor what beds might precede it, because the base is cut off on the Champlain overthrust. The formation appears on several faults and folds in the township of Monkton, 17 miles nearly south of Burlington, from which the formation is named, but in no place is anything lower than the Monkton exposed. In that town the Lower Cambrian Cheshire quartzite is brought in contact with the Monkton on the Monkton overthrust, which there separates the Central and Eastern sequences.

The Monkton consists very largely of a dense, fine-grained quartzite whose notable feature is its strong color. Red colors prevail, including all shades from brick red, brown, and buff, with a few beds of pure white quartzite None of these beds is traceable for any considerable distance The top of the formation has interbedded layers of a tough, fine dolomitic marble, also rather highly colored with red or pink. These beds are of the same composition as those of the overlying Winooski marble and make a transition between the two formations A few Lower Cambrian fossils have been found in the uppermost layers of the Monkton but are rarely to be seen until the thin slabs of quartzite have been exposed to the weather for a considerable period, thus leaching out a calcareous cement and permitting the interior structures

to be exposed. Cross-bedding, ripple marks, and trails of animals are numerous in the formation, showing that it was produced in shallow waters.

The Monkton quartzite is eroded very slowly so that it forms mountains or high hills, by which its course may be readily traced. It is considerably dissected by faults, so that the quartzite forms few continuous ridges but rather a lot of irregular, elevated tracts. This relation is very well seen around Mt. Philo in Charlotte, 14 miles south of Burlington. The most notable of the Monkton quartzite mountains is Snake Mountain, 6 miles northwest of Middlebury, which is a remnant of the Champlain overthrust plate, lying on Ordovician shale. West of this lie the low limestones and shales of the Western sequence, while east of it are other limestones of the same sequence, appearing through a great fenster in the overthrust. The rigidity of this formation and its ability to carry on the overthrust plate is well exhibited in this region.

Winooski marble —This formation consists of very massive, tough, and thick-bedded dolomite with the basal passage beds already mentioned The formation is marked by the strong reds, browns, and pinks like those seen in the Monkton Some layers have these colors strongly mottled with buff or white in very irregular patterns and have long been used for ornamental marble. The original quarry was on the north bank of Winooski River at Burlington, and the principal quarries are in Swanton, six miles northerly from St Albans The mottled marble there abuts against the Champlain overthrust and forms a striking contrast with the light marbles of the Chazy and Beekmantown on the other side of the fault The beds of the Winooski marble resist erosion very strongly and outcrop freely, thus furnishing a fine key rock. There is some interbedding between the Winooski marble and the overlying gray dolomite of the Mallett. A minor peculiarity of the Winooski is the series of very thin siliceous seams which project in wavy lines from the surface of the massive dolomite. Fossils are extremely rare in this marble but a few have been found The strongly mottled beds seem at first glance to be fossiliferous, but probably are not.

Mallett dolomite —This dolomite is exposed in the bluffs around Mallett Bay northwest of Burlington. Excepting the few basal passage beds the formation consists mainly of massive light or dark gray dolomite. With this are interbedded seams and layers of dolomitic sandstone which in the northern part of the region expand to form quartzite beds as much as 10 feet thick. These are most prominent

north of St. Albans, and their white reefs stand in relief above the dark gray dolomite. This is very striking near the Canadian boundary where the quartzite beds are cut off one after another against the Champlain overthrust. A few fossils of Lower Cambrian age have been found in this formation, mostly in slabby layers in its upper part. The dolomite resists erosion, especially in its quartzite beds, and makes considerable ridges separated by drift-filled valleys.

Parker slate.—This formation is named from its excellent exposures around the sides of the Parker Cobble and on the old Parker farm. It there contains large numbers of Lower Cambrian fossils and is the celebrated locality from which Walcott was able to make his first analysis of the Taconic system of Emmons and demonstrate the existence of beds older than the Upper Cambrian. It has long been the most important Cambrian formation of the region. This formation is the same as that previously called "Colchester" by the present author and is renamed because of the poor exposure of the formation in Colchester and, indeed, anywhere south of Parker Cobble. A full section of the formation is exposed at Parker Cobble together with the overlying and underlying formations.

The formation consists mainly of slaty shale which is dark gray or slightly color banded and which contains considerable original mica. This mica permits the layers to be split readily and the fossils to be uncovered. There are also in the formation a few sandy layers and some lenses a few feet thick of a gray dolomite which weather with a prominent brick-red surface. A notable feature in the slate appears about seven miles north of St. Albans in the form of massive, blunt lenses of blue limestone surrounded by the slate. These have the same form and relations as the limestone reefs of the Upper Cambrian Highgate slate.

The formation represents a sharp change in lithology from the preceding dolomites, and no interbedding has been noted. The top of the formation, however, is marked by a decided unconformity, by which the formation is reduced to almost nothing from a maximum thickness of perhaps 100 feet. The unconformable contact of the overlying Milton dolomite upon the Parker slate is well exposed a few yards north of the highway from St. Albans to St. Albans Bay, and also about one-half mile south of the same highway. At the locality north of the highway the Milton consists of dolomite conglomerate containing large boulders of dolomite and slabs and pebbles of the fossiliferous Parker slate. The fossils both in the pebbles and in the matrix were determined by Schuchert to be of Lower Cambrian age. South

of the latitude of Burlington there are no known exposures of this formation. There are numerous localities, however, where it may be present but concealed by glacial drift.

The slate is a weak formation and is only rarely exposed at the valley margins. A good exposure of this is seen in a pit for road material about one mile northwest of Highgate Center, where some 20 feet of slate containing Lower Cambrian fossils are exposed Above the slate and forming the crest of the hill on the east lies the Milton dolomite, there consisting mainly of dolomite conglomerate. Between the two formations there is a distinct unconformity, on which beds of both formations are cut out North and northeast from this locality at scattered points in the minor valleys there are other outcrops of slate, probably Parker

Milton dolomite—The Milton as here defined is characteristically a dolomite, but it is one of the most variable formations in this region. It varies in thickness from perhaps 700 feet down to 8 or 10 feet, and it varies in character from massive gray dolomite, fine and coarse-grained, thick bedded and slabby, through sandy dolomites and quartzites to a coarse dolomite conglomerate. In the upper part of the formation, and only where it is thick, considerable black chert is found in the dolomite.

The rocks just mentioned are those which are usually seen in the Milton, but there is an apparent component of the formation which is very rarely visible, i e, a series of slate layers interbedded with the other rocks They have thus far been found in full only in the section below Highgate Falls. At extreme low stages of the River a considerable section is exposed which is not ordinarily visible and in this are found numerous layers of slate. These slates have the same characteristics as the Parker slate, but a few fossils were found in them, which are stated by Schuchert to be of Upper Cambrian age, thus classing them with the Mill River conglomerate. Numerous minor unconformities were brought out between the slates and the conglomerates and sandstones of the Milton, which emphasizes clearly their torrential nature. This general conglomeratic nature is also characteristic of the Milton as here defined in practically all of this area and is most prominent from the latitude of Milton northward to Canada. In some places these dolomite conglomerates consist of angular fragments of all the kinds of rock which appear as layers in the formation, and thus may be properly classified as intraformational. The coarse basal conglomerates, however, which carry boulders 3 or 4 feet in diameter, and many rounded fragments of dolomite as well as slabs of Parker slate, are not intraformational.

In the original definition of the Milton by the writer the formation included at the top about 80 feet of conglomerates, some of them dolomite conglomerates and others largely of limestone, with a few feet of very fossiliferous limestone containing many Upper Cambrian fossils. The general conglomeratic habit of these upper beds was the same as that of the beds below, and for lack of decisive evidence the lower part of the formation was also included in the Upper Cambrian Since that time Middle Cambrian fossils have been discovered by Howell in the St. Albans region in the St. Albans slate, which underlies the Mill River conglomerate and Highgate slate and overlies the Milton dolomite Since the discovery of the Middle Cambrian formation the author has mapped the region in detail and has continued the tracing of the Middle Cambrian beds, so that the position of much of the original Milton beneath the Middle Cambrian is assured. The upper part of the original Milton seems clearly of Upper Cambrian age, and it is excluded from the Milton as here defined, and is named Mill River conglomerate.

Shelburne marble—This formation consists almost wholly of white marble of fine and medium grain with a few layers of light colored dolomite. The formation is exposed for only a few miles north of the latitude of Burlington, being there faulted out and eroded Southeast of Burlington, and particularly in the township of Shelburne, from which it is named, the formation becomes prominent and occupies several parallel belts. From this point southward the marble is almost continuous and is only interrupted for short distances by changes in the folds It is represented in the Eastern sequence by a marble formation of the same character which is almost continuous through the quarry region of Middlebury, Brandon, Proctor, and Danby In all these places the marble is overlain by the Williston limestone, but between them there is a very important unconformity. In the St. Albans region between the horizons of the Shelburne and the Williston there appear the St. Albans slate, the Mill River conglomerate, and the Highgate slate. The basal contact of the Shelburne with the Milton dolomite is very seldom seen, but apparently there is a transition between them

The Shelburne marble contains no fossils so far as is known, but it is uniform and is a regular unit in the Lower Cambrian succession of the eastern part of the Valley. It also occupies the same position in the Lower Cambrian Eastern sequence. Assignment of the Shelburne to the Lower Cambrian is also supported by the presence of white marble boulders in the conglomerates of the Upper Cambrian in most of their exposures.

St. Albans slate—Middle Cambrian fossils were found in this formation by Howell at the west border of the city of St. Albans, after a thorough search which was prompted by the statement in the literature that Middle Cambrian fossils had been found in St. Albans. By careful work Howell discovered several other localities for the Middle Cambrian and also for Upper Cambrian fossils in the overlying Highgate slate These beds have been traced by the writer into the western part of the township of Milton. Apparently they are cut out a few miles south of Highgate Center between the Milton dolomite and the Highgate slate There is, however, a fair prospect that they can be identified in one of the beds of slate which is exposed only at low water below Highgate Falls. The formation contains only slate, which is dark gray and locally banded, and is micaceous like the Parker slate

Mill River conglomerate.—This formation is one of the most interesting in this region, although it is one of the smallest It is seen at St Albans resting on the Middle Cambrian slate, and also in fine exposures at Missisquoi River just below the falls at Highgate Center, 9 miles nearly north of St Albans The formation is of Upper Cambrian age, and an abundant fauna is secured from some of its limestone layers. The fossiliferous beds form slabs an inch or two thick which are very characteristic, and their fragments appear as angular slabs in the later conglomerates. When the beds were first described by the writer they were included in the Milton dolomite because each formation was notably conglomeratic and because no fossils were known in the lower part of the Milton The later discovery of the Middle Cambrian slate compelled the separation of these two formations, and the name "Missisquoi" was given to the conglomerate as the only name that seemed available Unfortunately, it had been used in another sense for several Cambrian formations east of the Green Mountains and thus should not be used here. The name Mill River had already been selected by Howell and the writer for a conglomerate three miles southwest of St Albans, which was later shown by the writer's detailed tracing to be the same formation. At the Mill River section the Middle and Upper Cambrian beds are exposed and contain fossils

This formation is characteristically a conglomerate, and the fossiliferous limestones are only a small part of the formation. All of the conglomerate beds contain angular fragments of dolomite, sandstone, and quartzite, such as are found in the older Milton dolomite. Several layers also contain fragments and boulders of blue limestone and white

marble, many of which exceed 3 feet in diameter. The marble appears to have been derived from the Shelburne marble, which is the only rock of the sort which can be older than Upper Cambrian The blue limestone boulders resemble some of the limestones of the Ordovician, but they resemble equally well the blue limestones found in the reef deposits of the Lower Cambrian Parker slate, found a few miles southwest of Highgate Center In the original description of the conglomerates by the writer it was noted that they strongly resemble tillites No scratched pebbles have been found in the formation, however, and that question must remain in abeyance.

The conglomerate outcrops freely and forms low ridges, but it is doubtless covered in many regions by the glacial drift Many good sections, however, fail to show the conglomerate, so that it is not continuous throughout the region This conglomerate bears a very strong resemblance to the Lower Ordovician Corliss conglomerate, which is quite natural in view of the derivation of the boulders from the same sources. The Corliss, however, contains pebbles of uppermost Cambrian ("Saratogan") age. The difficulty of separating the two is most considerable for a few miles from Highgate Falls south to Skeels Corners, for the Mill River conglomerate together with a part of the Milton dolomite is repeated by a thrust fault and now lies on top of the Highgate slate The thrust fault is well exposed in the gorge at Highgate Falls. Similarly fine exposures of the formation are seen from one to two miles west of Georgia Center, resting on the Milton dolomite

Highgate slate.—This slate rests upon the Mill River conglomerate in the gorge at Highgate Falls, and is named from that locality Most of the formation is exposed between the conglomerate and the thrust fault above mentioned, and consists in the main of dark gray or black slate, usually well banded and with pronounced cleavage Some layers might properly be called phyllite The banding is so regular that its resemblance to glacial varves has already been noted and the glacial origin of the slate discussed in connection with the underlying conglomerates In addition to the usual banded slate several beds of dolomite a foot or so thick are found in the lower part of the slate. These are tightly folded and in places torn apart, thus giving a better idea of the great deformation of these rocks than is obtained from the slates In the upper part of the section in the gorge there are numerous sandy seams from 1 to 2 feet thick which appear in the slate a few miles to the south. The highest part of the slate comes in about one-half mile to the north of the gorge in the outskirts of Highgate Center.

There and at numerous localities up to the Canadian border the slate is interbedded with thin layers of blue limestone and gray dolomitic limestone. These give a strongly striped appearance and in a good-sized ledge are plainly visible at a distance. Strong folding has magnified the apparent size of the formation, which seems to be 500–600 feet thick.

A remarkable phenomenon in the Highgate slate is the development in many localities of large masses of limestone entirely surrounded by the slate. They occur usually in the upper part of the formation above the horizon of limestone layers above mentioned. They are found from Canada southward nearly to Burlington They resist erosion more than the surrounding slates and hence form prominent points in the landscape, resembling gigantic turtles. The maximum size so far found is about 200 feet long and 80 feet wide, and they project from 10 to 20 feet above the general level. Numerous contacts with the slate have been found and the ends of the limestone bodies are very blunt and rounded so that they give the effect of having pushed aside the slates during their growth. The slates pass above and beneath the margins of the limestone bodies and can be seen completely surrounding the small bodies They occur in clusters as well as individually, a relation which is very well seen about two miles northwest of Georgia Center

These limestone bodies are, for the most part, made up of massive, dense blue limestone without any visible structure. In the large masses, however, there is apt to be a portion of the mass showing a subdivision of the blue limestone into roughly rounded bodies separated by narrow zones of brownish impure limestone and also a secondary quartz partly filling the spaces between the limestones These rounded areas of blue limestone are the cross sections of columns which stand nearly vertical and can be seen in solution cavities to extend down at least 5 feet from the surface The most notable example is 2 miles west of north from Georgia It is evident from these exposures that the structure of these limestones is not due to any sedimentary process, but is the result of some reef-building organism. Some of these reefs appear to have persisted to the end of the Highgate deposition, for they are directly overlain in places by the Corliss conglomerate, and appear to have furnished much local material for the conglomerate A good example is also seen 2 miles nearly west of Georgia Center.

Upper Cambrian fossils were found by Walcott in this formation, and others were found by the writer in thin limestone seams in High-

gate Center. The latter were decided by Walcott to be of Upper Cambrian age. The formation runs in a continuous belt from the Canadian border to the latitude of Burlington, where it is cut off by the Hinesburg overthrust. There is no known contact between the Highgate and the next younger formation, the Williston limestone. The two lap past each other for a few miles east of Burlington but they appear in different folds, so that the exact nature of the contact is undetermined. In and south of that tract, however, the Williston rests upon the Lower Cambrian Shelburne marble, and the Highgate, Mill River, and St. Albans formations are absent. Since these formations represent the Middle and Upper Cambrian, there is a great hiatus between the Williston and Shelburne formations.

Williston limestone.—This formation is named from its exposures in the western part of the township of Williston about 5 miles southeast of Burlington. It is cut off at the north in Milton by faulting and erosion but extends southward to the limits of the Central sequence. It also appears in the eastern sequence and forms a practically continuous belt in the western part of that sequence southward through Vermont. It contains fossils in its outcrops in Williston and South Burlington, and also about a mile west of Brandon in the Central sequence which were pronounced by Schuchert to be of Upper Cambrian ("Saratogan") age.

The formation consists of a thick series of beds of hard gray dolomite and of blue limestone largely altered to marble. The beds are from a few inches to a few feet thick and are greatly disturbed. The hard dolomite layers are folded and broken apart into segments, and the marbles are mashed and squeezed into the gaps and spaces between the dolomite bodies. It is only in the few layers of dolomite and limestone which are least disturbed that the fossils are found. The Williston is an important formation but its thickness can only be estimated roughly on account of the great deformation which it has suffered. It covers broad areas, however, and is doubtless as much as 500 or 600 feet thick. The contact of the limestone with the Shelburne marble is a sharp one and the change in sedimentation is very marked. Probably half of the Williston consists of dolomite, while the Shelburne marble has very little. The repeated change from dolomitic to calcareous beds in the Williston is in great contrast with the even deposition in the Shelburne.

Corliss conglomerate.—This conglomerate, like the Mill River conglomerate, is one of the striking and important formations of this region. It rests upon the Highgate slate and forms a series of lenticu-

lar deposits between the Highgate and overlying Georgia slate, at intervals from Canada to their end, five miles south of St. Albans. There is little difference in appearance between these two conglomerate formations, but their stratigraphic associations differ widely. The Mill River contains Upper Cambrian fossils and fossiliferous pebbles of the Lower and Upper Cambrian. The Corliss contains the same Cambrian pebbles, and also some of "Saratogan" age which were found at the Corliss Ledge, 5 miles northeast of St. Albans These "Saratogan" forms show the Corliss to be post-Upper Cambrian, as they are the same as fossils found in the Williston limestone. The conglomerate is overlain by the Georgia slate, which contains fossils immediately above the contact and at a still higher horizon The "Saratogan" fossils of the Williston limestone and its pebbles in the Corliss conglomerate were determined by Schuchert He also made a preliminary assignment of the Georgia slate to the post-Beekmantown part of the Ordovician. On further consideration he now considers the Georgia slate to be of Beekmantown age This automatically assigns the Corliss conglomerate to the early part of the Beekmantown

The Corliss conglomerate consists in the main of pebbles and boulders of various limestones, marbles, and dolomites, most of them being limestone. The thin slabs of fossiliferous Upper Cambrian limestone derived from the Mill River conglomerate are numerous and conspicuous Fossiliferous pebbles of Lower Cambrian limestone are occasionally found, and one boulder of blue limestone with apparent cryptozoa lies in the conglomerate at Marye ledge two miles south of St. Albans. A limestone boulder 60 feet long and about 30 feet wide was found in the conglomerate 4 miles north of St Albans. In the same exposures there were many boulders up to 5 or 6 feet in diameter. In the original description of this region by the writer the very strong resemblance of the Mill River and Corliss conglomerates led to their description as one formation—the "Swanton conglomerate" Later detailed mapping and study showed that there were two conglomerates and that the Mill River—the older one—was placed by thrust faulting south of Highgate Center in the position of the Corliss on top of the Highgate slate, thus causing the confusion of the two.

Georgia slate.- This formation is the youngest known in the sequence and outcrops continuously from the Canadian border to the northern part of the township of Georgia, 6 miles southerly from St. Albans. The formation consists almost wholly of slate of a dark gray color and is fine-grained. It is strongly cleaved and usually not well banded, and the structure and thickness of the slate can only here and there

be determined. The formation occupies an area which widens to 3 miles at the Canadian boundary. It is probably 1,000 feet or more in thickness. A very few limestone beds are found in this slate and in one of them, 4 miles northeast of Highgate Center, were found the fossils of Beekmantown age already mentioned. The bottom layers also contain fossils of the same age, near the Canadian border.

The only change from the usual type of slate in the Georgia appears in its northeastern portions where there are massive and thick bedded layers occasionally sandy in texture. These have a whitish color on the weathered surfaces. Most of the slates are very similar to those of the Highgate and the two can scarcely be separated without fossils. Where the Highgate contains numerous limestone beds or the limestone reefs the two formations can be distinguished. Wherever the Corliss conglomerate is found it furnishes a satisfactory means of drawing the boundary of the Georgia slate. In the wider northern areas of the slate there are found here and there ledges of the conglomerate, some of them of considerable size. The structural relations of the slate to these conglomerates can not now be determined.

(To be concluded)

BOTANY.—*New Central American Asteraceae collected by H. H. Bartlett*.[1] S. F. BLAKE, Bureau of Plant Industry.

Study of the specimens of Asteraceae (except Eupatorieae) collected by Prof. H. H. Bartlett in British Honduras and Guatemala during the 1931 expedition of the Carnegie Institution and the University of Michigan has brought to light three new species, as well as a new genus represented by a plant long ago described by Bentham as an *Oliganthes*. These are described below, and with them a new *Aplopappus* collected in Tamaulipas by Prof. Bartlett in 1930.

Harleya Blake, gen. nov.

Capitula homogama tubuliflora. Involucri oblongo-turbinati phyllaria multiseriata gradata sicca cuspidato-acuminata erecta. Receptaculum parvum nudum planiusculum leviter alveolatum. Corollae regulares aequales, tubo cum faucibus infundibuliformi, limbo 5-fido. Antherae base alte sagittatae, auriculis obtusis ecaudatis. Styli rami subulati hirtelli. Achenia turbinata 4–5-costato-angulata saepius costis 1–5 minoribus praedita inter costas glandulari-papillosa. Pappus coroniformis cartilagineus crassus obscure crenatus.—Herba perennis subsimplex bipedalis stolonifera, foliis alternis petiolatis ovalibus vel rhombico-ovalibus penninerviis repando-

[1] Received May 20, 1932. Based (in part) upon collections made by an expedition of the Herbarium and the Museum of Zoology of the University of Michigan collaborating with the Department of Historical Research of the Carnegie Institution of Washington in a biological survey of the Maya area.

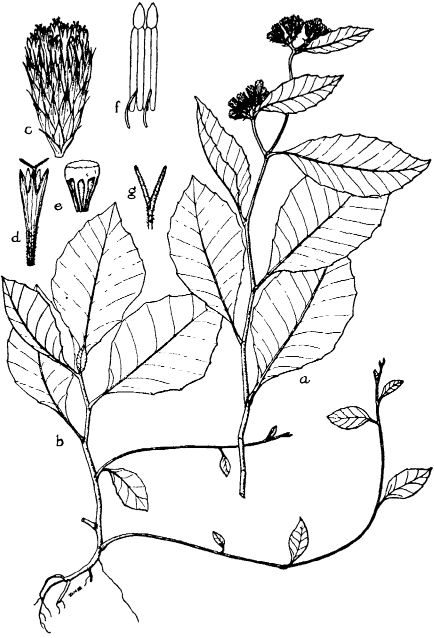

Fig 1—*Harleya oxylepis* (Benth) Blake—*a*, upper part of plant, × 1/2, *b*, plant with runners, × 1/2; *c*, head, × 3, *d*, corolla, × 3 5, *e*, achene, × 9, *f*, stamens, × 9; *g*, style branches, × 6 Fig *b* from *Bartlett* 13142, other figures from *Bartlett* 12042

denticulatis supra glabris subtus dense albido-tomentosis, capitulis mediocribus parvis 8–9-floris subsessilibus in cymulas parvas densas brevipedunculatas terminales et e axillis supremis orientes aggregatis, corollis purpureis Species typica *Oliganthes oyxlepis* Benth

Harleya oxylepis (Benth) Blake

Oliganthes oxylepis Benth , Benth & Hook Gen Pl **2:** 233. 1873, Blake in Standl. Contr U. S Nat Herb **23:** 1418 1926

YUCATAN (or Tabasco): *E P Johnson* 21 (type coll photog and fragm. in U S Nat Herb., ex herb N Y Bot Gard)

BRITISH HONDURAS: Cocquericot, El Cayo District, 16 March 1931, *Bartlett* 12042, Tea Kettle, El Cayo District, 12 May 1931, *Bartlett* 13142 — The habitat is given as follows Alluvial soil on river banks, several feet above water but subject to occasional overflow, only flowering, apparently, if in good light (Bartlett in litt)

This interesting plant was briefly diagnosed by Bentham in 1873, in his discussion of *Oliganthes* in the Genera Plantarum, in the following words. " in altera (*O oxylepide*, Benth) ex Yucatan Americae centralis E P. Johnson n 21, capitula 8-flora, pappo plane nullo, folia in hac dentata, in caeteris integerrima " Dr H A Gleason, in his first revision[2] of the North American Vernonieae, retained it in *Oliganthes*, with the statement that he had seen no specimens, but in his treatment of the tribe in the North American Flora (**33:** 102 1922) excluded it without otherwise accounting for it Some years later, having found a sheet of the type collection among some specimens sent me for study from the New York Botanical Garden, I presented a description in Standley's "Trees and shrubs of Mexico " The excellent specimens collected for Dr Bartlett agree perfectly with the original collection and show that the species can not be retained in *Oliganthes*, but must be made the type of a new genus most closely related to *Struchium* (*Sparganophorus*).

The genus *Oliganthes*, which has received several synonyms, was originally described by Cassini (1817 and 1818) and based on a plant (*O triflora* Cass) said to have been collected in Madagascar by Commerson Recent authors have considered the original habitat erroneous, and in both Bentham and Hooker's Genera Plantarum and O Hoffmann's treatment of the family in Engler & Prantl's Naturlichen Pflanzenfamilien the genus is reported from America only Humbert, however, in his study of the Compositae of Madagascar, mentions not only the original specimen of Commerson but also recent collections by Perrier de la Bathie and Scott Elliot No specimens of the Madagascar plant are available to the writer, and it seems necessary for the present to follow the course of all recent authors and consider the Madagascar species congeneric with the American species currently referred to the genus. A recent study of these, and of the very closely related and perhaps not satisfactorily separable current genera *Piptocoma* Cass and *Ekmania* Gleason, has shown that *Oliganthes oxylepis* Benth. can not be

[2] Bull. N Y Bot Gard **4**: 235 1906

retained in *Oliganthes*. All the true species of *Oliganthes* are shrubs or trees, with small or very small heads aggregated in dense terminal corymbiform panicles Their pappus is typically double, the outer of numerous usually persistent squamellae, free or united into a crown, the inner of 2–13 deciduous often twisted linear paleae, sometimes simple, of squamellae only, these free and very small or larger and united into a lacerate crown, in one species (*O condensata*) the pappus is sometimes wanting (?). The species of *Piptocoma* and *Ekmania* are also woody, with somewhat larger and more loosely arranged heads, but with similar pappus

Oliganthes oxylepis, as contrasted with the true species of the genus, is a low perennial herb bearing leafy stolons from the lower or sometimes even from the uppermost axils The heads are larger and very much less numerous, and the involucre is composed of very numerous cuspidate-acuminate phyllaries The short, thick, somewhat turbinate achene is unequally and subalately 4–5-angled and usually with 1–5 weaker ribs, and obscurely glandular-papillose between the ribs, the thickened, cartilaginous, obscurely crenulate, annular pappus is 0 3–0 5 mm high and about a third to a quarter as long as the achene Its herbaceous habit and cartilaginous annular pappus remove the species very definitely from the *Oliganthes* group and place it next to *Struchium* P Br (*Sparganophorus* Gaertn), a monotypic genus of tropical America and Africa In that genus the tiny corollas are only 3–4-toothed, the achenes 3–4-angulate-ribbed, and the anther bases acuminate It is consequently necessary to place *O oxylepis* in a new genus, which I have much pleasure in naming *Harleya* in honor of Prof Harley Harris Bartlett, whose labors in various fields of American and foreign botany have been numerous and fruitful

Aplopappus bartlettii Blake, sp nov

Herba perennis pedalis dense glandulari-pubescens et patenti-pilosa, rhizomate tenui repente, caules suberecti paullum ramosi dense foliosi, folia uniformia spathulata sessilia subintegra ca 3 cm longa 8 mm lata obtusa 1-nervia utrinque viridia, capitula longe pedunculata mediocria flava radiata solitaria terminalia et in axillis superioribus, involucri 8 mm alti gradati phyllaria linear-lanceolata longe acuminata, radii ca 19, achenia compressa 10-costata hispidula, pappi straminei setae ca 20 subequales achenio duplo longiores

Plants 20–30 cm high, the stems erectish or ascending, scattered on slender running rootstocks, often short, only 4–10 cm high, terminated by a single head and continued by 2 or 3 branches from near the apex, these branches sometimes similarly terminated and prolonged, pubescence of short hairs about 0.5 mm long, tipped with dark glands, and of long white hairs about 2 mm long, all wide-spreading, leaves 2 5–3 5 cm long, 4–10 mm. wide, obtuse, apiculate, narrowed to the rounded scarcely or not clasping base, erectish, pubescent like the stem and ciliate, entire or with one or two small blunt or acute teeth on each side, 1-nerved and sometimes with an obscure pair of lateral nerves, peduncles monocephalous, naked, 4–8 cm long, very slender, pubescent like the stem, heads about 1 5 cm wide, disk equaling involucre, this turbinate-hemispheric, 4–5-seriate, not strongly graduate, reflexed in age, the

outer phyllaries with herbaceous center and narrow scarious margin, the inner mainly subscarious, with narrow green midline; rays yellow, fertile, in age purplish outside, pilose toward tip of tube and on back of limb below, the tube 3 mm long, the lamina nearly linear, 3-denticulate, 3-4-nerved, 6.5 mm long, 1.3 mm wide; disk flowers about 50, fertile, yellow, their corollas glabrous except for a few short hairs on the teeth, 4.5 mm long (tube 1.8 mm, throat slender-funnelform, 2 mm, teeth ovate, 0.7 mm long); achenes of ray and disk similar, obovate-oblong, somewhat compressed, 1.5 mm long, rather sparsely hispidulous; pappus 1-seriate, 4.5-5 mm long, of stiffish essentially equal finely hispidulous bristles; anthers subentire at base, with short linear-subulate terminal appendages; style branches 0.8 mm long, the oblong stigmatic region 0.5 mm long, the narrowly triangular acuminate hispidulous appendages 0.3 mm long.

MEXICO: Above La Vegonia near San José, Tamaulipas, alt. 1000 m., 3 July 1930, *Bartlett* 10046 (type in herb. Univ. Michigan).

That plant is perplexingly intermediate between *Aplopappus* and *Chrysopsis*. In appearance and practically all features except the pappus it agrees with *Chrysopsis*, particularly with *C. pilosa* Nutt. The strictly 1-seriate pappus, however, makes it necessary to refer it to *Aplopappus*, where the only section that can receive it is *Isopappus*. The two species referred to that section in the late Dr. H. M. Hall's monograph of "Haplopappus" are both annuals and too different from *A. bartlettii* to require detailed comparison. *Chrysopsis pilosa*, although very similar in general appearance, is an annual and has a strongly differentiated outer pappus, broadly obovoid achenes, and various other distinctive characters.

Wedelia adhaerens Blake, sp. nov.

Herba verisim. erecta dichotome ramosa; caulis dense hamato-hispidulus sparsissime hispidus; folia remota ovalia vel ovali-ovata acuta basi late rotundata inconspicue serrulata triplinervia chartacea aspere pubescentia; capitula parva radiata aurea apice caulis et ramorum ternata sublonge pedunculata; involucri ca. 3-seriati subaequalis ca. 7.5 mm. longi phyllaria ovato-lanceolata acuminata hispido-strigosa et strigillosa supra medium herbacea suberecta; pappus cyathiformis longe stipitatus.

Apparently herbaceous, 0.5 m. high and more; stem slender, 2.5 mm. thick, densely hispidulous with short mostly spreading hamate hairs and especially below sparsely hispid with ascending hairs; leaves opposite; petioles 1-2 mm. long, hamate-hispidulous and rather densely hispid; blades of larger leaves 3-3.5 cm. long, 1.5-2.5 cm. wide, remotely and obscurely callous-serrulate with 4-6 teeth on each side, above dull green, densely and evenly hamate-hispidulous with spreading hairs, sparsely tuberculate-hispid with antrorse-curved hairs, beneath scarcely lighter green but slightly shining, densely hamate-hispidulous on surface, on veins and veinlets sparsely antrorse-hispid, triplinerved from near base and loosely prominulous-reticulate beneath; upper leaves and those of branches smaller but otherwise similar, 1-2.3 cm. long, 8-13 mm. wide; heads 1.5 cm. wide, usually in clusters of 3 at tips of stem and branches, the peduncles slender, usually naked, pubescent like the stem, the terminal one about 1 cm. long, the lateral at maturity 2.5-5 cm. long, sometimes bearing a bract and a secondary head; involucre campanulate, 7.5-9.5 mm. high, about 3-seriate, subequal or slightly graduate, the two outer series of phyllaries lanceolate to lance-ovate, 1.3-3 mm. wide, densely hispidulous and less densely tuberculate-hispid with ascending hairs, indurated

and whitish about to middle, the acuminate or acute callous-pointed herbaceous tip loosely erectish, pubescent on both faces, the inmost series shorter and without herbaceous tip, disk 6–7 mm. high, about 4 mm. thick; rays about 6, yellow, pistillate, the tube 2 mm long, essentially glabrous, the lamina oval, 3-denticulate, up to 9 mm long, 5 5 mm wide, about 13-nerved, hispidulous and gland-dotted dorsally, disk flowers about 12, their corollas yellow, essentially glabrous except on the hispidulous teeth, 5 mm long (tube 2 mm, throat slender-funnelform, 2 5 mm, teeth broadly ovate, 0 5 mm), pales scarious, sometimes purplish, acute or obtusish, sometimes shortly 3-lobed, hispidulous-ciliolate on margin and keel above, ray achenes obcompressed, plumpish, obovate, subalate-margined, 1-ribbed on inner face, mottled, glabrous except at the slightly hispidulous apex, truncate or emarginate at apex, 2-calloused at base, 4-4 2 mm long, 2 3–2 5 mm wide, their pappus a ciliolate cup 0 4 mm high, borne on a usually slender stipe 0 5-0 8 mm long, the whole 1-1 2 mm long, readily detergible at maturity, mature disk achenes not seen, their pappus (young stage) a lacerate cup 0.7 mm. high, connate with 2 awns 1-1 3 mm long

GUATEMALA In logwood swamp, Dos Arroyos, Dept Petén, 15 March 1931, *Bartlett* 12111 (type no 1,540,626, U S Nat Herb)

Nearest *Wedelia parviceps* Blake, and essentially indistinguishable as to heads and involucre, except for their slightly larger size In that species, however, the leaves are ovate to lanceolate, not half as wide as long, the achene is only about two-thirds as long, and its subsessile or short-stipitate pappus-cup, including its stipe, is only half as long

Melanthera parviceps Blake, sp nov

Herba opposite ramosa, caulis quadrangularis breviter strigosus, folia oblongo-triangularia vel lanceolata acuminata basi cuneata crenato-serrata tenuia utrinque viridia hispidula et hispido-hirsuta, minoribus saepius leviter hastatis, capitula parva anthesi 3–6 mm diam apice caulis ramorumque irregulariter cymosa-paniculata, pedunculis saepe 2–4-cephalis, involucri ca 3 mm alti phyllaria ovata acutiuscula strigosa et ciliata apice breviter herbacea, paleae receptaculi brevissime acutatae

"Fragile herb, 2 m high, spearmint-scented," stem bluntly 4-angled, up to 4 mm thick, purplish, rather sparsely short-strigose, principal internodes 1-1 5 dm long, leaves opposite, petioles slender, hispid-hirsute, 1–4 cm long, the larger narrowly cuneate-winged at apex for about 1 cm (passing into the blade), blades of larger leaves triangular-oblong, about 14 cm long, 4-4 5 cm wide, short-cuneate at base, crenate-serrate nearly throughout with about 35 pairs of subequal rounded apiculate teeth about 1 mm high and about 3 mm apart, triplinerved, lightly prominulous-reticulate beneath, above dark green, evenly but not densely hispidulous and hispid-hirsute, beneath scarcely lighter green, hispidulous on surface, hispid-hirsute on veins and veinlets, smaller leaves usually slightly hastate at base, more sharply toothed, 7 cm long and 3 cm. wide, or smaller, heads usually in 2's-4's at apex of stem and branches, in fruit 5 mm high, 6-8 mm thick, the peduncles strigose, 1-4-headed, mostly 1–5 cm. long, the pedicels usually 0 5–2 5 cm long, involucre 2-seriate, subequal, 3–3 5 mm high, appressed, the phyllaries ovate, acutish, callous-tipped, strigose, ciliate above, disk in flower about 4 mm. high, 6 mm thick, flowers about 24, their corollas white, hispidulous on teeth, 3 2 mm long (tube 0 7 mm, throat campanulate, 1 5 mm, teeth triangular-ovate, 1 mm long), pales hispidulous and sometimes purplish above, shortly and rather bluntly pointed, 4 2 mm long (the narrowed tip 0 8

mm. long), achenes plump, lenticular, hispidulous on apex, 2.2 mm long; pappus caducous, of 3–4 (or more?) subequal slender hispidulous awns 1.5 mm long or less.

BRITISH HONDURAS: In ravine, Little Mountain Pine Ridge, El Cayo District, 1 March 1931, *Bartlett* 11882 (type no. 1,540,623, U. S. Nat. Herb.).

Related to *Melanthera purpurascens* Blake, of Chiapas, but a much larger, coarser, erect plant, with even smaller heads, usually grouped at tips of branches, and less pointed pales.

Calea fluviatilis Blake, sp. nov.

Fruticulus pedalis, caules tenues ramulosi foliosi minute hispiduli glabrescentes, folia angustissime lineari-lanceolata ca. 2.5 cm longa 1.5 mm lata coriacea remote calloso-serrulata subglabra glanduloso-adspersa, capitula discoidea parva 13-flora 3–7 terminalia cymosa, in pedunculis ca. 1 cm longis, involucri 4–5 mm. alti phyllaria exteriora pauca triangularia supra medium vel maxima ex parte herbacea glanduloso-adspersa interioribus ovalibus vel ovatis subscariosis apice saepe purpurascentibus subglabris aequalia vel breviora, pappi paleae 20 achenus hispidulis subduplo longiores.

Undershrub 25 cm. high, several-stemmed from a thick woody flattened caudex 2.5 cm. wide, stems erectish, somewhat trichotomously branched, in age with numerous small branchlets, subterete or subangulate, minutely hispidulous on the younger parts with erectish hairs, glabrescent; leaves opposite, petioles 1 mm. long, blades 1.3–2.8 cm. long, 1–2 mm. wide, acuminate to each end, obtusely callous-tipped, remotely 2–3-denticulate or serrulate on each side with low callous teeth, triplinerved, somewhat revolute-margined, deep green, dotted on both sides with sessile shining yellowish glands, otherwise glabrous or sparsely and obscurely strigillose beneath; heads about 7 mm. high, 4 mm. thick, in terminal clusters of 3–7, the peduncles very slender, 8–12 mm. long, hispidulous and glandular-dotted; involucre 3–4-seriate, more or less distinctly graduate, the outermost phyllaries triangular, obtusely callous-tipped, 3–5 mm. long, 0.7–1 mm. wide, appressed, coriaceous-herbaceous above middle or nearly throughout, 1-ribbed and with an obscure pair of nerves, dotted with sessile glands, the others yellowish-brown, usually purplish-tipped, rounded, several-vittate; corollas yellow, glabrous, somewhat zygomorphic, 4.8 mm. long (tube 2.2 mm., throat 1–1.2 mm., teeth unequal, 1.2–1.8 mm. long, 2 or 3 being less deeply cleft than the others); pales oblong, 5 mm. long, obtuse, sometimes abruptly and obtusely short-pointed, glabrous, yellowish, about 3-vittate; achenes blackish, erectish-hirsutulous except toward base, 2 mm. long; pappus paleae about 20, narrowly linear-lanceolate, acuminate, subequal, hispidulous-ciliolate, 3.5 mm. long.

BRITISH HONDURAS: On stones in Río Privación, Mountain Pine Ridge, El Cayo District, 26 Feb. 1931, *Bartlett* 11790 (type no. 1,540,622, U. S. Nat. Herb.).

A member of the subgenus *Eucalea*, very distinct from any other North American species in foliar characters.

Liabum dimidium Blake, sp. nov.

Frutex scandens, caulis sordide arachnoideo-tomentosus glabrescens et praecipue supra pilosus vel pilosulus pilis sordidis patentibus multiloculatis; folia late ovata petiolata serrulato-denticulata triplinervia supra tenuiter arachnoidea glabrata subtus albido-tomentosa, capitula 7–11-flora discoidea numerosissima, paniculam latam efformantia, involucri ca. 4-seriati 5–6 mm

alti pappo subduplo brevioris phyllaria ovata ad oblongo-linearia obtusa vel rotundata ciliata; achenia dense hispidula, pappus albidus 6 5 mm longus duplex, exteriore setuloso ca 1 5 mm. longo

"Lax scrambling shrub, 6 m high," stem (above) subterete, striatulate, 6 mm thick, rather thinly arachnoid-tomentose, glabrescent, sordid-pilose or -pilosulous especially in inflorescence, leaves opposite, petioles slender, 1 3–3 cm long, thinly arachnoid, glabrescent, blades of larger leaves 9–12 cm long, 6–9 5 cm wide, relatively thin, acute, at base broadly cuneate or rounded-cuneate, serrulate-denticulate above the mainly entire base with very slender teeth about 0 6 mm long and 3–6 mm apart, beneath compactly but not thickly dull-whitish-tomentose, panicles terminating stem and upper branches, together forming a loose pyramidal panicle about 28 cm wide and 20–30 cm. long, thinly arachnoid and rather densely sordid-pilosulous with many-celled spreading hairs, the heads partly sessile, partly on pedicels up to 4 mm. long, involucre 4–5-seriate, strongly graduate, the 2–3 outer series of phyllaries ovate, somewhat fleshy, striate when dry, dull green, obtuse, ciliate and sparsely sordid-pilosulous, the 2 inner series linear-oblong, about 1 mm. wide, thinner, not striate, sordid-ciliate, erect, receptacle shallowly alveolate, the edges of the alveolae minutely hispidulous, corollas yellow, pilosulous on upper part of tube, 8 mm long (tube slender-funnelform, 3 3 mm long, throat thick-cylindric, 2 mm long, teeth linear-triangular, 2 7 mm. long, hispidulous at apex), achenes (not truly mature ?) 1 3 mm long; pappus yellowish-white, double, the outer setulose, about 1 5 mm long, scarcely wider than the inner, the inner of hispidulous bristles bent at apex. 7 mm long

GUATEMALA Tikal, Dept Petén, 12–15 April 1931, *Bartlett* 12602 (type no 1,540,627, U S Nat Herb)

A member of the group separated by Rydberg under the generic name *Sinclairia* Hook. & Arn, and related to *Liabum polyanthum* Klatt and **Liabum brachypus** (Rydb) Blake[3] The former has a longer involucre (about 7–9 mm high), nearly or quite equaling the pappus, and the inner phyllaries are strongly spreading or reflexed above at maturity *Sinclairia pittieri* Rydb, the type of which I have studied, is not separable by any real character from *L. polyanthum* *Liabum brachypus* lacks the sordid spreading hairs of the new species, and has a somewhat longer involucre (about 7 mm) and a dense inflorescence The specific name of the new species refers to the relative length of the involucre and the fruiting head.

[3] *Sinclairia brachypus* Rydb N Amer Fl **34**: 299 1927

ZOOLOGY —*Two new pocket mice from Arizona* [1] E. A. GOLDMAN, Biological Survey.

When *Perognathus amplus* was described by Osgood in his revision of the genus (North Amer Fauna, No. 18, p. 32, Sept. 20, 1900) the type was unique Some subsequent efforts to obtain topotypes have been unsuccessful, owing perhaps to seasonal or cyclic variations in numbers. Over thirty specimens from various localities in the general region are, however, regarded as fairly representative. A series from

[1] Received June 16, 1932

the low, open, desert region of southwestern Arizona presents the decidedly paler coloration characterizing some of the other mammals of that area. Specimens from northwestern Arizona, south of the Grand Canyon, also exhibit a departure from the typical form. The new geographic races are differentiated as follows:

Perognathus amplus rotundus, subsp nov

Gila Pocket Mouse

Type.—From Wellton, Yuma County, Arizona No 250470, ♂ adult, U. S National Museum (Biological Survey collection), collected by Bernard Bailey, November 9, 1931 Original No A4353, X catalogue No 27029

Distribution—Desert region of southwestern Arizona, and probably adjoining parts of Sonora

General characters—A large, light-colored subspecies, closely allied to *Perognathus amplus amplus*, of central Arizona, but ground color of upper parts a decidedly paler shade of pinkish buff, less obscured by black on face and along flanks, postauricular spots rather prominent; cranial characters also distinctive

Color—*Type* Upper parts near pale pinkish buff (Ridgway, 1912), purest on upper surface of muzzle, sides of head, shoulders, flanks and outer surfaces of thighs, the top of head and back finely lined with black, under parts, forelimbs and hind feet white, ears pinkish buff externally, except anterior fold which is dusky, thinly clothed internally with blackish hairs, and distinctly edged with white at posterior base, small dusky areas at base of vibrissae on sides of muzzle (not continued in a narrow line across face as in typical *amplus*), tail thinly haired, slightly crested and tufted terminally, grayish above, whitish below, becoming dusky at tip

Skull—Very similar in general to that of *P a amplus*, but more robust, rostrum and nasals distinctly broader, mastoids broader anteriorly, bulging upward more prominently along outer border of parietal, but narrower, less inflated posteriorly, dentition about as in *amplus*

Measurements—*Type*: Total length, 170 mm, tail vertebrae, 90, hind foot, 21 Average of five adult topotypes 161 (155–165), 86 (82–95), 20.4 (20–21) *Skull* (type): Occipitonasal length, 24.2, greatest breadth (across auditai bullae at meatus), 15.2, zygomatic breadth (posteriorly), 13.3, interorbital breadth, 5, length of nasals, 9.3, width of nasals (in front of incisors), 2.5, interparietal, 3.2 x 3.4, maxillary toothrow (alveoli), 3.6

Remarks—The pallid general coloration and most notably the lighter head of *Perognathus amplus rotundus* readily distinguishes it externally from *P a amplus*, and the skull differs markedly from that of the type of the latter Intergradation may, however, be assumed

Specimens examined—Ten, all from the type locality

Perognathus amplus pergracilis, subsp nov.

Hualpai Pocket Mouse

Type—From Hackberry, Mohave County, Arizona (altitude 3500 feet) No. 227528, ♂ young adult, U S National Museum (Biological Survey collection), collected by E. A Goldman, September 14, 1917. Original number 23304

Distribution—Desert region of northwestern Arizona, south of the Grand Canyon.

General characters.—Similar to *P. a. amplus*, but of more slender proportions; ground color of upper parts paler pinkish buff. Differing from *P. a. rotundus* in slenderness, and darker general tone of upper parts due to density of overlying black-tipped hairs, especially on head.

Color.—*Type*: Ground color of upper parts pale pinkish buff, purest along lateral line from cheeks to thighs, the head and back moderately and uniformly overlaid with black; under parts, forelimbs and hind feet white; ears pinkish buff externally, except anterior fold which is dusky, thinly clothed internally with blackish hairs; tail grayish or light brownish above, becoming darker toward tip, whitish below to small terminal tuft which is dusky all around.

Skull.—Similar to those of *P. a. amplus* and *P. a. rotundus*, but smaller and relatively narrower in greater dimensions, mastoids and audital bullae relatively smaller and much less inflated, the mastoids less rounded and produced posteriorly beyond plane of occiput; interorbital region actually as well as relatively broader.

Measurements.—*Type*: Total length, 143 mm.; tail vertebrae, 80; hind foot, 21. Average of three adults from Little Meadows (west of Kingman, Arizona): 154 (151–156); 86 (80–90); 21.5 (21–22). *Skull* (type): Occipitonasal length, 22; greatest breadth (across audital bullae at meatus), 12.8; zygomatic breadth (posteriorly), 11.7; interorbital breadth, 5.4; length of nasals, 8.5; width of nasals (in front of incisors), 2.2; interparietal, 2.8 x 3.9; maxillary toothrow (alveoli), 3.5.

Remarks.—*Perognathus amplus pergracilis* combines the pale buffy ground color of *P. a. rotundus* with the more obscured head and dorsum of *P. a. amplus*, due to overlying dusky hairs, and it differs notably from both in slenderer proportions.

Specimens examined.—Total number, 16, all from Arizona as follows: Beal Spring (2 miles from Kingman), 3; Big Sandy Creek, 1; Hackberry (type locality), 5; Little Meadows (west of Kingman), 3; Peach Springs, Hualpai Indian Reservation, 3; Signal, 1.

SCIENTIFIC NOTES AND NEWS

The honorary degree of doctor of science was conferred on Dr. D. J. McAdam, Jr., of the Bureau of Standards at the commencement exercises of Washington and Jefferson College on June 4, 1932.

Obituary

Dr. Louis W. Austin, international authority on radio transmission, and member of the staff of the Bureau of Standards, died in Washington on June 27 at the age of 64.

Dr. Austin received the degree of doctor of philosophy at the University of Strasburg (Germany) in 1893. He served as professor of physics at the University of Wisconsin and at the Reichsanstalt in Berlin. In 1904 he came to the Bureau of Standards and began researches in wireless telegraphy. From 1908 to 1923 he served as head of the Naval Research Laboratory, returning to the Bureau of Standards in 1923.

Dr. Austin was a member of the American Physical Society, Washington Academy of Sciences, Philosophical Society of Washington, American Institute of Radio Engineers and other scientific organizations. He received the medal of the American Institute of Radio Engineers in 1927.

Dr. Austin's researches on radio transmission received wide recognition and he had only recently been elected to the presidency of the International Scientific Radio Union.

station maintained at the mine. To be able thus to have an accurately determined mean annual temperature at the collar of the shaft and a temperature determination 4200 feet vertically below is indeed a fortunate combination, and for this reason the geothermal gradient of 153 feet per degree Fahrenheit at the Kennedy mine is held to be entitled to much confidence.

The mean annual temperature at the collar of the Central Eureka shaft, which is 1610 feet above sea level, was estimated to be approximately 58° Fahrenheit, by applying a correction of 0.5° on account of the 180 feet difference in elevation between the Central Eureka and Kennedy mines. By using this figure a gradient of 160 feet per degree Fahrenheit was found to obtain at the Central Eureka mine. At the Plymouth mine no surface temperature records were available, and the gradient of 145 feet was computed from underground data.

There are therefore three determinations of geothermal gradients along the 10-mile segment of the Mother Lode in Amador County, ranging from 145 feet to 160 feet per degree Fahrenheit. In no one of the three sets of determinations are there sufficient data to allow least-square adjustments, and 150 feet per degree Fahrenheit will serve as a round number for the geothermal gradient at the Mother Lode in Amador County.

Johnston has not explained the marked discrepancy between his value of the geothermal gradient at Grass Valley—190 feet—and that earlier determined by Lindgren—122 feet. It would appear worth while for him to show that his data represent a homogeneous set of data, the only kind suitable for least-square computations. In my opinion data obtained from levels in different mines, in rocks of differing conductivities (granodiorite, diabase, and others), in rocks traversed by veins, faults, "crossings" and in places containing standing water, are very heterogeneous, and mathematical manipulation of such heterogeneous data is likely to obscure information of geologic significance.

GEOLOGY.—*Geothermal gradient of the Mother Lode belt, California: A reply* [1] W. D. JOHNSTON, JR., U. S. Geological Survey. (Communicated by W. H BRADLEY).

In the preceding paper Knopf offers the following objections to the conclusions contained in a recent paper[2] of mine.

[1] Received June 15, 1932 Published by permission of the Director, U S Geological Survey

[2] W D JOHNSTON JR *Geothermal gradient at Grass Valley, California* This JOURNAL 22: 267-271 1932.

1. "*** temperature observations from two mines (the Plymouth and the Kennedy) situated 10 miles apart were used to compute a gradient, but this procedure is not permissable, as the gradients at the two mines are most likely to be different."

2. "*** it was assumed that the collars of the shafts of the two mines are at the same altitude *** (whereas they) differ by 330 feet.***"

3. "The mean annual temperature, however, was not *assumed*, but *** was taken from a 10-year series of daily readings at a Weather Bureau station maintained at the mine."

4. "Johnston has not explained the marked discrepancy between his value of the geothermal gradient at Grass Valley—190 feet and that earlier determined by Lindgren—122 feet."

5. "It would appear worth while for him to show that his data represent a homogeneous set of data, the only kind suitable for least square computations"

These objections will be discussed in the following order—2, 3, 1, 4, and 5. The first three refer to Knopf's data for the Mother Lode and the last two to my Grass Valley data.

2 The assumption that the collars of the shafts of the two mines are at the same level was erroneous From the corrected elevations H. C. Spicer has computed the reciprocal gradient to be 160 5 feet per degree Fahrenheit, as shown in column A of Table 1 This is nearer Knopf's value of 150 feet per degree than my previous erroneous value of 192.3 feet per degree. As the exact elevations of the collars of the Plymouth and Kennedy shafts are not available, Mr Spicer has also computed geothermal constants based upon the maximum error in the assumed collar elevations of these mines These values are given in columns B and C of Table 1.

3. The observed mean annual temperature of the air is *not* the mean annual temperature of the rock surface Numerous observers have found that the air temperature just above the ground surface is from 1 to 10 degrees Fahrenheit lower than the temperature just beneath the ground surface [3,4] As shown in Figure 1 in my previous paper, the observed mean annual temperature at Grass Valley, a record based upon daily readings during 22 years, is 7 degrees higher than the computed subsurface temperature Altitude, topographic situation, pre-

[3] J A McCutchin *Determination of geothermal gradients in oil fields located on anticlinal structures in Oklahoma* Bull Amer Petroleum Inst **205**, figs 3–9, pp 58–61 1930

[4] A J Carlson *Geothermal conditions in oil-producing areas of California.* Bull Amer Petroleum Inst **205**, figs 9–84, pp 121–139 1930

TABLE 1 —GEOTHERMAL CONSTANTS FOR THE MOTHER LODE, CALIFORNIA (COMPUTED FROM KNOPF'S DATA BY H C SPICER)

Mine	Altitude of collar of shaft	Level	Vertical depth below shaft collar	A				B			C		
						475-2770 ft			425-2795 ft			525-2745 ft	
				Depth below sea level	Rock temp	Computed temp	Observed minus computed	Depth below sea level	Computed temp	Observed minus computed	Depth below sea level	Computed temp	Observed minus computed
Plymouth	1,100 (±50)	1,600	1,575	475	72 0	72 0	0 0	425	72 0	0 0	525	72 1	−0 1
do	do	4,000	3,600	2500	86 0	84 7	+1 3	2550	84 8	+1 2	2450	84 5	+1 5
Central Eureka	1,610	4,400	4 095	2485	83 6	84 6	−1 0	2485	84 4	−0 8	2485	84 7	−1 1
Kennedy	1,430 (±25)	4,200	4,200	2770	86 0	86 3	−0 3	2795	86 3	−0 3	2745	86 3	−0 3
Constants						a = 69 08 b = 0 00623 $1/b$ = 160 5 r = ±0 80			a = 69 45 b = 0 00603 $1/b$ = 165 7 r = ±0 70			a = 68 70 b = 0 00644 $1/b$ = 155 4 r = ±0 90	

vailing wind direction, and numerous other factors[5] are responsible for discrepancies of this kind When the mean annual temperature of the air is used in the computation of a geothermal gradient that value is necessarily an "assumed value," y.

1. An error is probably introduced by the use of temperature data from mines 10 miles apart but it is believed to be of lesser magnitude than the error introduced by the use of the mean annual temperature of the air as the assumed value y

4. Lindgren's[6] value of 122 feet per degree for the geothermal gradient at Grass Valley is based upon three sets of temperature readings in the Idaho-Maryland Mine,—one in the drain tunnel, a second on level 15, 1,523 feet vertically below the drain tunnel, and a third in a stope 40 feet above level 16.

My values are based upon 22 sets of readings uniformly distributed through a vertical range of 3,600 feet. As all the temperature readings lie on a smooth curve with a maximum difference between the observed and computed values of only ±0 8 degrees and a probable error of ±0.26 degrees, the more recent work seems to me to be the more acceptable

5 Knopf's last point questioning the homogeneity of the Grass Valley data is answered by the distribution of the temperature readings in Figure 1 of my earlier paper Any marked difference between the conductivity of diabase and granodiorite or the presence of deep artesian circulation along the veins or "crossings" would be shown by an undulation in the depth-temperature curve

In conclusion it appears that a little more weight should be given to the value of the Mother Lode geothermal gradient of 160 with a possible range of ±5 feet per degree as computed by the method of least squares from all of the underground data available than to Knopf's value of 150 feet per degree

[5] E M FITTON and C F BROOKS *Soil temperatures in the United States* Mo Weather Rev **59**. 6-16 1931

[6] WALDEMAR LINDGREN *Gold-quartz veins of Nevada City and Grass Valley districts, California* U S Geol Survey, Ann Rept **17**. Pt 2, 170-171 1896

GEOLOGY —*Stratigraphy and structure of Northwestern Vermont*— II[1] ARTHUR KEITH, U S Geological Survey

EASTERN SEQUENCE

The rocks of this sequence are well seen a few miles north of Middlebury and near Brandon, and they can also be followed southward

[1] Received June 6, 1932 Published with the permission of the Director, U. S Geological Survey Concluded from Vol 22, No 13, p 357, this JOURNAL.

from Rutland to Massachusetts. One formation of the Archean and three formations of the Algonkian are present in this sequence; these are the granite and granitoid rocks of the Archean, and the graywacke, marble, and phyllite of the Algonkian. They are confined to the frontal ranges and hills of the Green Mountains and are seen in most sections into the Mountains. There is an unconformity between these formations and the Cheshire quartzite of the Lower Cambrian, so that in many places the Moosalamoo phyllite is removed and the marble forms the top of the Algonkian As the unconformity is followed northward the phyllite becomes much thicker, but southward the phyllite, marble, and graywacke all disappear and the Lower Cambrian rests directly upon the Archean granite. This unconformity accordingly is one of the greatest, if not the greatest, in the region.

Nickwaket graywacke—This formation extends in the Green Mountains from the Canadian border for a considerable distance south of the latitude of Rutland It invariably forms high ground and mountains, one of which, Nickwaket Mountain, a few miles southeast of Brandon, gives the formation its name. The formation consists entirely of schistose rocks with a large percentage of graywacke and feldspathic quartzite The schists and schistose coarser beds are composed of variable amounts of quartz, muscovite, biotite, and chlorite with local developments of magnetite The graywacke beds at the top of the formation are coarse and in many places conglomeratic, while at its base there are important conglomerates. These conglomerates have lenticular forms, being not everywhere present, and they consist of pebbles and boulders of the older rocks, largely quartz, granite and gneiss. Rarely these boulders are as much as two feet in diameter. The best development of this conglomerate, a few miles southeast of Middlebury in the town of Ripton, was described by Dale The upper graywacke beds are seen in contact with the overlying marble at Forestdale

Forestdale marble.—There is a sharp change from the graywacke to this marble, the latter being mainly calciferous, while the graywacke contains no calcite. The marble is massive and greatly metamorphosed in most localities, with growth of many silicate minerals. It has colors ranging from white to light gray, buff, and cream mottled, and weathers usually with a marked reddish-brown surface. There are considerable differences in the thickness of the marble with a minimum of perhaps 200 feet in the district northeast of Brandon. Southward the marble thickens until it is two or three times as thick southeast of Brandon, and then thins again to the east of Rutland.

Northward it is fairly continuous to the Canadian border. At Forestdale, five miles northeast of Brandon, there is an excellent section from the upper graywacke conglomerate of the Nickwaket to the basal conglomerate of the Cambrian.

Usually the marble makes low ground, as is conspicuously the case in the valley northward from Forestdale and through Silver Lake. Just below the outlet of Silver Lake there is a very fine section showing the details of the unconformity between the marble and the basal conglomerate of the Cambrian. At this point the Lower Cambrian Cheshire quartzite makes the beautiful Llana Falls

Moosalamoo phyllite.—The phyllite, a fine-grained black rock, consists mainly of quartz and muscovite with a little biotite and disseminated iron ore. The formation does not change within the region being described except in thickness, as already stated It ranges from nothing at Llana Falls to a probable thickness of 500 feet upon the south and east slopes of Moosalamoo Mountain, only a mile to the north It is pinched out in the general latitude of Middlebury but goes still farther to the north.

Cheshire quartzite – This formation is continuous from Cheshire in northwestern Massachusetts to Canada, except for short stretches of a few miles each where it is cut out by faults. Locally it forms the steep, high front of the Green Mountains and numerous ledges make clear its presence Huge cliffs are formed by the quartzite at many places, as in Wallingford, 9 miles south of Rutland, or the quartzite may make the entire face of the mountain in a dip slope, as in Hogback Mountain, northeast of Middlebury. This mountain has an anticlinal structure and the quartzite pitches northward under the younger dolomites so that the mountain ends abruptly The lower part of the formation and the underlying Algonkian formations are shown at Forestdale, 3 miles northeast of Brandon.

By far the greater part of the formation consists of massive, white, vitreous quartzite; this is particularly so in the upper beds. In the middle of the formation thin layers of black slate are interbedded with the quartzite but are not sufficiently well defined to be a regular subdivision of the formation. The chief departure in the lithology of the formation is the basal conglomerate. This is present practically everywhere and occasionally forms a coarse, massive deposit. The conglomerate of this sort consists largely of pebbles of quartz, quartzite, and granite with some additions of marble and slate from the underlying formations. Coarse conglomerate of this nature is found 3 miles southeast of Brandon and resembles strongly the conglomerate at the

base of the Nickwaket graywacke. Doubtless the two were largely derived from the same source. The formation varies considerably in thickness and has a probable maximum of about 800 feet in Wallingford.

Rutland dolomite.— This formation consists almost wholly of dolomite. Its color is usually light or dark gray and it has a fine or medium grain. Most of it is thick bedded though there are a few slabby layers. In the district about 10 miles northeast of Middlebury, in the towns of Bristol and Monkton, the bottom of the formation consists of a mottled light buff or pink dolomite marble which rests directly upon the massive quartzite of the Cheshire. South of that tract the marble beds disappear and the gray dolomite comes down to the Cheshire In many places there is a transition from the Cheshire quartzite into the dolomite through sandstone and sandy dolomite. This is particularly clear on the south slope of Blueberry Hill, 3 miles north of Rutland, where the syncline of Rutland Valley rises to the north. In the middle of the formation is found a thin horizon of light colored limestones. These appear just north of Rutland but cannot be traced far. Near the top of the formation there is a thick bed of dolomitic sandstone which makes prominent outcrops near Rutland. Below this there are 100 feet or more of dark blue, dolomitic limestone. Fossils were found in this formation in the Rutland Valley by Wolff and Foerste which showed it to be of Lower Cambrian age. A few fossils were found by Walcott in the topmost beds of the Cheshire quartzite, also of Lower Cambrian age.

The strata of this formation, like those of the preceding Cheshire, are very massive and compact and have acted as a unit to minimize the folding, thus the syncline of Rutland Valley is one of the few open synclines in the region. Its western limb is found in Pine Mountain and its eastern limb, which is locally faulted off, appears along the front of the Green Mountains. The strata in the middle of the fold are nearly horizontal. This open fold was thrust westward against the highly deformed beds of the upper part of the sequence.

Danby formation.—This formation is a departure from the usual carbonate deposits of the Valley. There is a great variety in the beds of this formation, but they are separated from the other formations chiefly by the amount of sandstone and quartzite and by their vari-colored dolomites. The quartzite beds are composed of clean white sand in separate layers a foot or two thick, interbedded with massive dolomites, like those of the Rutland, and with transitional strata, like sandy dolomites and sandstone. In the usual section the quartzite beds stand out like white reefs above the other layers. Some peculiar

dolomites also are found with a range of colors, including pink, buff, and green. These are very fine-grained and tough and together with the quartzites form ridges. Associated with these beds are thin seams and layers of greenish slate.

The beds of this formation are considerably folded, as would be expected from their variable and thin-bedded character. They usually dip at high angles and exhibit a great variety of small and large folds. This folding makes it difficult to estimate the thickness, but the formation is probably in the vicinity of 300 feet thick.

Wallingford dolomite.—The boundary between the Wallingford and Danby formations is not sharp and is marked mainly by the close of the strong quartzite sedimentation, the variable colors of the dolomite, and the slate beds. It is well exposed in the township of Wallingford, its type locality. The Wallingford dolomite consists mainly of light and dark gray dolomites like those of the Rutland dolomite. With these are interstratified thin beds of dolomitic or quartzitic sandstone of a light gray color. The formation has no other peculiarities and is of about the same thickness as the Danby.

Clarendon Springs dolomite.—This formation consists wholly of fine-grained dolomite of a light gray or dove color, and its type locality is Clarendon Springs, Vt. It differs from the Wallingford dolomite mainly by the absence of sandstone or quartzite. The formation grades upward into Shelburne marble without interbedding or other notable features, and is from 100 to 200 feet thick.

Shelburne marble.—This marble in the Eastern sequence is almost wholly composed of calcite marble, as it is in the Central sequence. The grain of the rock is medium in both sequences, but the color is more variable in the eastern sequence. White with blue mottling and banding are the common colors in the eastern sequence, and in some quarries there are found green bands in the white marble. These features bring out the close folding and flowage patterns in the marble and add to its value as ornamental stone. The quarries are found at short intervals through the entire extent of the formation in the eastern sequence, but they are mainly concentrated around a few centers, such as Brandon, Proctor, and Dorset, which is in the southern part of the state. The marble and associated formations are readily seen in the quarries around Brandon. There is a sharp change, but no visible unconformity, between the Shelburne and the overlying Williston limestone. As was noted under the Central sequence, formations of Middle and Upper Cambrian age are found north of Burlington in the interval between these two formations.

Williston limestone.—This formation in the Eastern sequence differs little from its exposures in the Central sequence. Fossils were found in Brandon which indicated its Upper Cambrian ("Saratogan") age, and very numerous ledges of the formation are to be seen in and around Brandon. The thickness of the formation appears to vary considerably in the Eastern sequence. It reaches its maximum thickness in the region around Brandon but thins materially along the eastern side of the Taconic Range It is nearly everywhere present, however, and its thinning is due to pinching out locally by folding. It is usually in contact with the overlying Ira slate and the separation between them is sharp. In some places, for instance 4 miles south of Brandon, normal sedimentary contacts show a change within a few inches from deposition of limestone to that of mud.

Ira slate.—This formation is well developed in the town of Ira, which adjoins West Rutland on the south. The formation consists entirely of a dark gray or black slate with very little banding or means of determining bedding, but a few feet of the slate in the lower part of the formation contains gray, siliceous seams. Secondary quartz is developed in these beds and they are tightly squeezed and dissected by folding so that locally the formation resembles a finely banded gneiss The sedimentary contact between the slate and underlying Williston limestone is sharp, as stated under the description of the limestone. The upper contact of the formation with the West Rutland marble is equally sharp, with a complete change from muddy sediments to pure limestone

At the north end of the main belt of the West Rutland marble the marble is seen to rest upon the slate in the old True Blue quarry, and the same situation is seen repeatedly in the northerly areas of the marble from three to four miles southwest of Brandon. The slate disappears at the north end of the Taconic Range, but southward it expands into a belt a mile or two in width There are no measures of the thickness of the formation, but it is probable that it is as much as 700 or 800 feet thick.

West Rutland marble.—This formation is best known from its use as ornamental stone, and West Rutland has long been the principal center of the marble industry. There is a considerable variation in the beds of the marble, and different quarries make a specialty of particular beds. A long line of quarries, old and new, lies along the eastern side of the marble belt. Most of these are now worked as underground mines instead of open-cut quarries. There are also a few quarries on the western side of the belt. The prevailing colors of

the marble are white, more or less banded with dark blue, mottled blue, and light gray. A few beds have a pale green banding, and in the quarries on the west side of the belt mottled, cream colored marbles are produced.

In the two northerly areas of the formation between Brandon and West Rutland the synclines in which the formation lies are shallower than that at West Rutland and only the lower part of the formation appears. In these areas the marbles are, in the main, dark blue, and there is a thin member of blue-banded limestones at the base This member also appears in the West Rutland area but it is thinner there and poorly exposed. These lower limestones contain a brachiopod fauna and many crinoid stems The upper marbles, particularly the bluish or blue-banded ones, have many large maclureas which appear best on the sawed surface of the stone These maclureas were the first fossils found in this region and have always been considered to be of Chazy age There are several small areas of this marble along the east side of the Taconic Range coming in and out against the Taconic overthrust These, too, contain fossils and are rather easily identified.

TACONIC SEQUENCE

The rocks of this sequence are found only in the Taconic Range and they form a very striking contrast with the beds of the same age which form the lower ground on the east and west The sequence consists almost wholly of slates, but it has also one thin formation of limestone and one of quartzite. By means of these two formations in the Lower Cambrian and one of red slate in the Ordovician, the order and structure of these formations can be disentangled The limestone (Beebe) contains a good Lower Cambrian fauna, and one of the slates has Middle Ordovician fossils Owing to the intense folding and faulting of this sequence, it has been necessary to follow out individual beds wherever they could be recognized For this purpose the limestone and quartzite above mentioned were of great service, as well as a few recognizable beds in the lowest formation—the Brezee phyllite. The entire section is exposed south of Stiles Mountain, near the north end of the Taconic Range.

Brezee phyllite - This formation outcrops around the north and northwest margins of the Taconic Range and is in contact with the underlying limestones and marbles at more places than any other formation. It thus forms the sole along which the Taconic overthrust block moved in coming to its present position What normally lies beneath the Brezee phyllite is not known because of this overthrusting.

The formation consists almost wholly of slate or phyllite of a dark or bluish-gray color. Much of it is banded with light gray, and its weathered surfaces are apt to have a brownish or dull greenish-gray color. Interbedded with the upper part of the phyllite is a thin calcareous quartzite, from 5 to 10 feet thick, which can be followed for considerable distances and is of much help in working out the fault system. Locally this quartzite passes into a sandy limestone. A few feet below this quartzite there is a zone of limestone lenses, all of which are small. The lowest part of the Brezee contains beds of cherty slate. Most of these are black and they are associated with purple slate of the kind that is so characteristic of the Lower Cambrian in the Taconic Range. These cherty beds resemble some of the Ordovician formations found farther to the southwest, but it is more likely that they represent a facies of the Cambrian. It is very difficult to make an estimate of thickness of this formation, but doubtless it exceeds 500 feet. The formation is named from Brezee Mill Creek, which flows out of the northeast end of the range.

Stiles phyllite—This formation is rather sharply distinct from the Brezee phyllite It is much more uniform in composition than the Brezee and its principal variations are those due to metamorphism. The formation consists almost wholly of slate or phyllite, with fairly numerous thin beds of quartzite. The whole formation, including the quartzite beds, has a rather plain greenish aspect due to secondary chlorite. This color is modified on weathered surfaces so as to become a greenish-gray or whitish-gray. Much quartz in thin lenses and veins appears in this formation, especially in its eastern areas, where it is most metamorphosed

The formation occupies a broad band along the east side of the Taconic Range and curving westward and southwestward around the end of the Range Along the east side metamorphism has proceeded locally to the extent that the rock is a schist composed mainly of quartz, sericite, and chlorite. The metamorphism is less in going northward and westward around the end of the range, so that at Stiles Mountain the phyllite presents a good average of the condition of the formation Westward from Stiles Mountain metamorphism is less and the formation may well be called a slate.

The thickness of this formation, like that of the Brezee, is wholly a matter of estimate. Each outcrop is full of minor folds and large folds and faults are noticed. It appears to be perhaps 400 or 500 feet thick at the north, but along the east side of the range it might

be double that thickness, for it forms important mountains and a belt of outcrop several miles wide.

Hubbardton slate.—There is no very sharp division between this slate and the Stiles phyllite, but the latter rather gradually merges up into the slate. The boundary is placed where the small quartzite layers end, which is also the horizon where the special colors of the Stiles end. The Hubbardton slate consists mainly of green slate with a variable amount of the purple slate. In some localities—notably in the western part of the Range—the purple is more common than the green in the upper part of the formation. These beds are very similar to those of the Bull slate which form the chief color horizon for the purple slates. The Hubbardton slate is named from its occurrence in the village of Hubbardton in the north part of the Taconic Range. It is probably about 300 feet thick, but this, too is only an estimate.

Barker quartzite.—This is one of the key rocks of the Taconic sequence, both because it is readily identifiable and because it makes sharp hills and ridges which plainly mark its position. The quartzite has a generally light or white color on weathered surfaces, but usually is more or less green when freshly broken. It varies also in coarseness from a dense rock with very fine grains of quartz to a coarse quartzite and locally a fine conglomerate. The coarser facies contain pebbles of various slates, quartzites, and a little limestone, probably derived from the older Cambrian formations. Possibly it is the same as the coarse quartzite and conglomerate of Bird Mountain a few miles east of Castleton. Barker Hill, for which the quartzite is named, is about 4 miles east of north from Castleton. The quartzite there and in the nearby Wallace Ledge is approximately 100 feet thick. Also it is about as thick in Ganson Hill, just north of the village of Hubbardton. In some places the quartzite thins down until it is barely recognizable.

Bull slate.—This is a comparatively thin formation between the underlying quartzite and the overlying Beebe limestone. The slate is usually of a purplish color more or less mixed with green. The three formations make a distinctive sequence which has helped much in unravelling the structure of the Taconic Range The Bull slate is named for the quarry on Bull Hill, 2 miles north of Castleton. It is the principal horizon which is worked for the purple and unfading green slates of the slate industry. The principal development of this industry is in the region of Fairhaven, Vermont, and Granville, New York, a few miles to the southwest of Castleton. The slate has a fine, even grain and smooth texture and the banding is so faint that

as a rule it does not affect the smoothness of the cleavage. There are only a few sandstone layers in the formation and occasionally a small bed of limestone appears in the upper part of the slate. No fossils are known from this formation, but its age is fixed by the fossiliferous limestone immediately overlying it.

Beebe limestone.—This limestone, which is only from 5 to 20 feet thick, would in most other regions be called a member of the slate formation; here, however, it is such an exceptional change from the usual character of the sediments and it is so fossiliferous that it is the most important formation of the entire Taconic sequence. It is named for its exposures near Beebe Pond, in Hubbardton, Vt. If drawn according to scale on the map, it would appear only as a line, but it is everywhere present at the proper horizon so far as known. The detailed sequence of formations already mentioned should include also the Hooker slate above the Beebe as being of equal importance. The fossils in this limestone were first found by Walcott in his study of the Taconic System of Emmons, and many collections have been made by later geologists. Although the formation is small, it commonly makes an impress upon the topography either as a line of low knolls or a shelf along the sides of hills made by other formations.

Hooker slate.—This formation is a notably black slate with less cleavage than is usual in this region. So far as is known, no fossils have yet been found in this formation. It appears, however, to be more closely associated with the Lower Cambrian formation than with the Ordovician ones which follow it. It is named from Hooker Hill, 2 miles north of Castleton. The formation in the Taconic Range is only in contact with the Ordovician Poultney slate in one locality, 6 miles southwest of Brandon, where a shallow syncline contains a little of the Ordovician formation. Southwest of the detailed area, however, and in the commercial slate belt around Fairhaven and Granville the contacts with the Hooker and the Ordovician slates are numerous. They are distinctly outlined by the numerous quarries in the Lower Cambrian Bull slate and a similar set of quarries in the Ordovician red slate. These formations run parallel for miles and the contact shows no signs whatever of variation This is all the more remarkable because at the horizon between the Hooker and the Ordovician slates there is found in northern Vermont a thick section of Middle and Upper Cambrian formations, to say nothing of the Lower Ordovician formations which outcrop within a few miles to the west or north. Thus a significant break in the section appears here with no physical evidence to indicate it. The formations on both sides are all thin, and even a

moderate amount of variation of the plane of hiatus would remove one or more formations.

Poultney slate.—This and the overlying Indian River slate are of Lower Ordovician age as indicated by the graptolites Graptolites were first found by Walcott in his early work on the Cambrian, and have since been found by many geologists. The Poultney slate, the lowest Ordovician formation, is named for its good exposures in the town of Poultney at the boundary of New York 7 miles southwest of Castleton. The formation consists mainly of gray slate which becomes lighter or even white on exposure. The most prominent feature of the formation is white or light gray chert which appears in very thin seams or in massive beds a foot or so thick. The formation resists erosion and it outcrops abundantly, making hills of considerable height. The normal succession of these beds following the Cambrian is well shown in a shallow syncline in New York just west of Poultney. Around the sides and end of this syncline can be traced the thin formations of the Lower Cambrian and Ordovician with perfect regularity. The fold pitches toward the south so that the youngest formations come in finally in that direction. The succession is almost equally clear for the small area of the formation already noted in the north end of the Range.

Indian River slate.—This is a formation which furnishes the well known red slate of the New York slate industry It consists mainly of bright red slate with a few thin seams or layers of fine green quartzite, the latter occur only locally The slate owes its bright red color to the iron oxide which it contains. It is of such a brilliant red that it is quarried a mile southwest of Poultney for use in making red paint. The dust derived from grinding the slate settles in the district surrounding the mill and gives a lurid color to the landscape. The name for the formation is taken from Indian River, a few miles south of Granville, New York, where several red slate quarries are located on the banks of the stream. It overlies conformably the Poultney slate, and is also conformable beneath an unnamed black slate.

Black slate.—The formation which overlies the Indian River slate has not yet received a name. It consists almost entirely of black or dark slate and thus contrasts strongly with the two preceding formations. These three Ordovician formations make a sequence which is as distinctive as the underlying Lower Cambrian sequence. The whole section—Lower Cambrian and Ordovician—is repeated over and over again in the Granville region. The principal feature which distinguishes this slate is the presence therein of numerous graptolites. These and the graptolites in the Poultney slate are assigned by

Ruedemann to the Normanskill horizon of the Albany, New York region.

GREEN MOUNTAIN SEQUENCE

General features.—The rocks of this sequence do not enter the quadrangles herein discussed and in which detailed work has been done. They lie to the east of the main crest of the Green Mountains in the eastern part of the Rutland quadrangle and are there exposed in long, narrow belts closely paralleling the western front of the Green Mountains. They are even more metamorphosed than rocks of the same age and character which appear in the Taconic Range. It is for comparison with the latter rocks that the Green Mountain formations are described. This is essential to an understanding of the Taconic overthrust in this region. The rocks of the Taconic Range, as already stated, are thrust from the east across the rocks of the east half of the Champlain Valley and into their present position. The sole of the overthrust passes upward into the air along the east side of the Taconic Range and does not come down again until far to the east in the middle of the Green Mountains. There, rocks of the same sort as those of the Taconic Range are found resting on the Plymouth marble, which is correlated with the Rutland dolomite of the Eastern sequence. The Plymouth marble rests upon the Cheshire quartzite and the latter upon the Algonkian formations of the Eastern sequence. These Algonkian and Lower Cambrian beds are repeated in parallel synclines which bridge across the anticlinorium of the Green Mountains in the northern part of the Rutland quadrangle. Southward from West Bridgewater, which is in the latitude of Rutland and about 18 miles to the east, the Plymouth marble forms a deep, narrow valley with a general southerly trend, bordered on the west by the Cheshire quartzite and on the east by the overlying Lower Cambrian schists. These are terminated a few miles east of West Bridgewater by a fault which extends far to the north and south. South of Ludlow, Vt the Lower Cambrian formations are cut out along this fault, but they reappear still farther south and form the Stamford Valley for a few miles north of North Adams, Mass The great fault there passes under the foot of Hoosac Mountain and thence far to the south in Massachusetts. This fault is the root of the Taconic overthrust as now delineated in the Taconic Range, and the two parts of it are barely one mile apart in Mt. Greylock and Hoosac Mountain. This part of the fault has recently been determined and mapped by Prindle in Massachusetts and for some distance north of Bennington, Vermont, while the northern part of the fault in the Taconic Range was first

proved and announced by the present writer in 1912. The entire length of the fault in Vermont and Massachusetts has been examined by the writer. The following brief description of the rocks of the Green Mountain sequence will serve to show their parallelism with those of the Taconic Range.

Pre-Cambrian rocks.—Formations of this age continue eastward from the Champlain Valley across the Green Mountains and differ little from place to place. In the latitude of Rutland the uppermost Algonkian formation—Moosalamoo phyllite—is not present, but farther north it comes in beneath the basal unconformity of the Cambrian. The description of the Algonkian formations of this section is practically the same as for the Eastern sequence.

Cheshire quartzite.—This Lower Cambrian formation consists mainly of quartzite, but it is thinner and more thinly bedded than the same quartzite of the Eastern sequence. The basal conglomerate of the formation is well shown, particularly in Sherburne, 12 miles northeast of Rutland, and there is the same central division of thin beds, now schists, parting the quartzites. A similar thinning and a similar subdivision may be seen in Stamford Mountain along the Massachusetts border.

Plymouth marble.—Exposures of this formation are few, as it is easily soluble and underlies the deep valley which bisects the Green Mountains in this region. The formation is composed chiefly of dolomitic marble which is grey or darkly mottled In the town of Plymouth limestone conglomerates appear in the formation, some of which have been used for ornamental stone known commercially as "Plymouth breccia." The marble is much folded and in places probably faulted so that its true thickness is unknown This formation is much thinner than the Rutland dolomite of the Eastern sequence with which it is correlated.

Albite schist.—Overlying the marble is a fairly thick body of dark schist or phyllite. Most of this consists of sericite and quartz sprinkled with iron oxide dust, but in many places it is speckled with secondary crystals of albite Locally these predominate and give a pepper and salt appearance to the rock There appears to be repetition of these schists with the marble, but it seems more probable that this is due to folding or faulting than to original deposition

Pinney Hollow schist of Perry.—This formation was recently described by Perry as overlying the albite schist. The exposures in Pinney Hollow in the town of Plymouth appear to be traversed by faults so that the section there is not certain. In West Bridgewater, a few miles to the north, an excellent section of the formation is exposed

which might well have been taken as the type locality. The formation is uniform throughout and consists almost entirely of chloritic, muscovite schist. This has a pale greenish color when fresh and on the weathered outcrops becomes greenish or whitish-grey with many rusty colored beds. Thin quartzite layers are found in the schist in many places and there is much secondary quartz in the lenses and veins. This formation is the precise duplicate of the Stiles phyllite of the Taconic sequence and like the latter forms high ground or mountains.

Quartzite.—Overlying the Pinney Hollow schist is a thin formation of quartzite of a dark bluish color but which weathers light gray or white on exposure. No name has been given to this formation for it has not been worked out in detail.

Ottauquechee phyllite of Perry.—This formation of Perry's marks an abrupt change from the preceding quartzite and green schist. It consists almost wholly of dark colored or black phyllite in which bedding is rarely seen. The formation is probably rather thick and similar in bulk to the Pinney Hollow schist of Perry. It appears to be terminated at the top by a fault, so that the nature of the formations immediately following is not evident here. Not far to the east—in the central part of the State—other Cambrian formations are reported, and above them several formations of phyllite and limestone in which Ordovician fossils have been found. Thus far, detailed work has not progressed so far that the relations of these groups can be stated.

GEOLOGY.—*Notes on the Puerco and Torrejon formations, San Juan Basin, New Mexico.*[1] C. H. DANE, U. S. Geological Survey.

During the summer of 1928 the writer was engaged in mapping for the U. S. Geological Survey the coal beds of the Upper Cretaceous Fruitland and Mesaverde formations in the southern part of the San Juan Basin, New Mexico. Plane table mapping was carried only to the top of the Ojo Alamo sandstone (which is in the opinion of the writer the uppermost Cretaceous formation of the region), but a reconnaissance map was made of the area to the north, where the overlying Puerco and Torrejon formations of Eocene age are exposed. The base of the still higher Wasatch formation was also sketched. (Figure 1.) Although the field study was thus limited, it seems worthwhile to correct some errors in the literature on the stratigraphy of the Puerco and Torrejon formations and point out that the Puerco formation may be present along the Rio Puerco, although the distinctive verte-

[1] Received May 31, 1932. Published by permission of the Director of the U. S. Geological Survey.

brate fauna by which alone it is recognized has not yet been found there.

The history of the names Puerco and Torrejon has been traced in detail by Gardner[2] and Bauer[3] and summarized by Reeside.[4] The name Puerco was applied by Cope[5] to the series of beds on the Rio Puerco which are now supposed to include both the Puerco and the overlying Torrejon formations Although he collected no fossils from these beds at the type locality, numerous vertebrate fossils were subsequently collected for him in the region west of the Puerco River

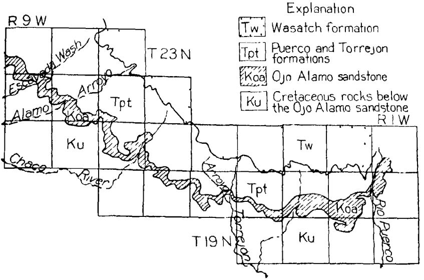

FIG. 1 —Geologic map showing distribution of Ojo Alamo sandstone and Puerco and Torrejon fomations between Escavada Wash and Rio Puerco, New Mexico

from what he believed to be the equivalent of his Puerco beds. He described these fossils as the Puerco fauna. Wortman[6] later recognized two distinct vertebrate faunas in collections made near Arroyo Torrejon and farther west. For the beds yielding the younger fossils he

[2] J H GARDNER *The Puerco and Torrejon formations of the Nacimiento group* Jour Geology **18:** 702-812 1910

[3] C M BAUER *Stratigraphy of a part of the Chaco River Valley* U S Geol Survey Prof Paper **98:** 276-277 1916

[4] J B REESIDE, JR *Upper Cretaceous and Tertiary formations of the western part of the San Juan Basin* U S Geol Survey Prof Paper **134:** 35 1924

[5] E D COPE *Report on the geology of that part of northwestern New Mexico examined during the field season of 1874* Chief Eng Ann Rept for 1875, pt 2, appendix G 1 1008-1017. 1875

[6] Cited by H F OSBORN and CHARLES EARLE *Fossil Mammals of the Puerco beds, collection of 1892* Am Mus Nat Hist Bull 7 2 1895

proposed the name Torrejon,[7] from exposures near the head of Arroyo Torrejon, and retained the name Puerco for the lower beds. His definitions have been since generally accepted. Gardner[8] used the term Nacimiento group (from the town of that name on the Puerco River, now known as Cuba) to include the two formations. This name has not been widely used

The Puerco and Torrejon formations are so similar in lithology that no separation between them has been made on this basis, although the faunas are so different that vertebrate paleontologists believe that they are separated by an important hiatus. The stratigraphic position of the hiatus has not been discovered. The vertebrate remains are found in thin fossiliferous horizons separated by much greater thicknesses of barren beds As defined by its fauna the Puerco formation is now known only for a distance of 35 miles along its outcrop from the head of the West Fork of Gallego Arroyo southeastward to Escavada Wash Since it is defined only by its fauna and no fossils have yet been found east of Escavada Wash, it is uncertain whether it is really present east of that locality. Reeside[9] preferred as a working hypothesis to consider that the Puerco formation is restricted practically to its present known area of outcrop and was overlapped elsewhere by the Torrejon formation. He based this suggestion on the demonstrated overlap of upper Torrejon over lower Torrejon north of San Juan River, from which the inference was logically drawn that the overlap might be progressive and the lower Torrejon have overlapped the Puerco beds to the north. If the disappearance of the Puerco fauna to the north were to be explained thus, it seemed likely to Reeside that a similar overlap might explain the non-discovery of the Puerco fauna east of its known extent Some support for this suggestion existed in the supposed thinness of the barren zone beneath Torrejon fossils on Arroyo Torrejon and the Rio Puerco, and the failure of careful search to disclose Puerco fossils near the Rio Puerco. The supposed thinness of the barren zone in this eastern area was based upon the sections given by Gardner[10] which have been subsequently modified and interpreted both by Sinclair and Granger[11] and by Reeside [12]

[7] Cited by W D MATTHEW *A revision of the Puerco fauna* Am Mus Nat Hist Bull 9. 260 1897

[8] J H GARDNER *op cit* 713

[9] J B REESIDE, JR *op cit* 35–36

[10] J H GARDNER *op cit* 717–723

[11] W J SINCLAIR and WALTER GRANGER *Paleocene deposits of San Juan Basin, New Mexico.* Am Mus Nat Hist Bull 33 308 1914

[12] J B REESIDE, JR *op cit* Pl 2

But the sections given by Gardner for the Arroyo Torrejon and Rio Puerco areas are certainly much too thin. As shown by his map, photograph, and sections, he interpreted the Ojo Alamo sandstone in the vicinity of the Rio Puerco as a sandstone in the lower part of the Puerco formation, and he included in the Puerco the beds below the Ojo Alamo and down to the Lewis shale. These beds are now known to include Kirtland shale, Fruitland formation, and Pictured Cliffs sandstone. If from the Rio Puerco section given by Gardner 281 feet of beds at the top which are probably to be referred to the Wasatch and 179 feet of Ojo Alamo and older Cretaceous beds at the base are excluded there remains 379 feet for the combined thickness of the Puerco and Torrejon formations. The thickness of the Puerco and Torrejon formations at this place however, is actually more than 630 feet as is shown by the section in Table 1

Gardner correlated the fourth member above the base in his Rio Puerco section (now known to be Ojo Alamo sandstone) with the third member above the base in his Arroyo Torrejon section, a 30 foot tan colored sandstone, and stated that this is a very persistent horizon marker and was traced continuously from the Nacimiento Mountains to the Arroyo Torrejon and beyond. This 30-foot tan-colored sandstone is quite surely Ojo Alamo and the 80 feet of shale below it is Kirtland shale Accordingly Gardner's Arroyo Torrejon section allows only 240 feet for the combined thickness of the Puerco and Torrejon formations An estimate by the writer, based on known contact elevations and locations and a *minimum* allowance for dip of 1 foot per 100 horizontally, gives a thickness, believed to be conservative, of 700 feet for the combined Puerco and Torrejon formations in the vicinity of Arroyo Torrejon. This does not seem excessive compared with the incomplete section of 570 feet of Puerco and Torrejon measured at the head of Ojo Alamo Arroyo, in T. 24 N., R. 11 W., by C M. Bauer and J. B Reeside, Jr.[13]

Sinclair and Granger[14] in correlating their sections with the sections published by Gardner state that "In the Arroyo Torrejon section of Gardner the full thickness of the Puerco is certainly not exposed. Of the 210 feet referred by him to that formation 100 feet is now known to belong to the Torrejon because Torrejon fossils in abundance are found at the point indicated in the section, 100 feet below his Puerco-Torrejon contact " The point indicated in the section is just above the 30-foot tan-colored sandstone which is most probably the Ojo Alamo sand-

[13] J. B REESIDE, JR *op cit* 67
[14] W. J. SINCLAIR and WALTER GRANGER *op cit* 308.

stone. Furthermore, on the same page they speak of "the discovery of Torrejon fossils immediately above the 30 foot bed of sandstone (third member above the base in the Arroyo Torrejon section)." If these correlations were accepted, the Puerco would be missing from

TABLE 1—SECTION OF PUERCO (?) AND TORREJON FORMATIONS, EXPOSED IN THE FRONT OF CUBA MESA, IN THE NORTHEASTERN PART OF T 20 N, R 2 W
MEASURED BY C B HUNT

	Feet	Inches
Wasatch formation		
Sandstone and conglomerate		
Puerco (?) and Torrejon formations		
Sandstone, argillaceous, tan	70	
Sandstone, light tan	12	
Sandstone, argillaceous, tan in lower part, gray above	48	
Clay, in alternating light and very dark gray bands	30	
Sandstone, gray, massive and cross bedded	12	
Clay, in alternating light and very dark gray bands	29	
Sandstone, tan, cross bedded	14	
Clay, sandy, gray, with some bands of dark gray clay	20	
Sandstone, gray, cross bedded	18	
Clay, in alternating bands of variable thickness, light and very dark gray	12	
Sandstone, gray, cross bedded	32	
Clay, in alternating bands of light and very dark gray	36	
Sandstone, gray, cross bedded	10	
Sandstone, with spheroidal concretions of dark manganiferous (?) material, more than a foot in diameter	3	
Sandstone, gray, cross bedded	10	
Clay, in alternating light and dark gray bands	70	
Sandstone, fine grained, light gray, with dark manganiferous (?) concretions	18	
Clay, in alternating light and dark gray bands	24	
Sandstone, fine grained, light gray	5	
Clay, in alternating light and dark gray bands, white at the base	26	
Coal	0	2
Clay, banded light and dark gray	15	
Shale, dark carbonaceous, not a persistent bed	0	6
Coal, a bed locally as much as one foot thick and continuous for three quarters of a mile	0	8
Clay, dark gray with some lighter gray bands	18	
Sandstone, fine grained light gray, of variable thickness	7	
Clay, light and dark in alternating bands	43	
Concealed for the most part but probably banded clay	50	
Thickness of Puerco (?) and Torrejon	633	4
Ojo Alamo sandstone		
Sandstone and conglomerate		

Arroyo Torrejon eastward It appears, however, that Sinclair and Granger were misled by the erroneously thin section given by Gardner into believing that the lower fossil horizon, 100 feet below the upper one, would fall just above the 30 foot sandstone (now recognized to be

the Ojo Alamo) However, they further state that the two Torrejon fossil horizons are exactly 100 feet apart and that both horizons were traced from the East Fork of Arroyo Torrejon to the west branch of Kimbetoh Arroyo Inasmuch as the Arroyo Torrejon collecting localities located on their sketch map and described in their text are in the face of the cliff capped by the basal sandstone of the Wasatch it appears most likely to the writer that both Torrejon horizons are actually well above the Ojo Alamo sandstone

Accordingly the writer believes that in the Arroyo Torrejon section there are probably 450 feet of beds below the lowest Torrejon fossils, in which quite possibly there are beds equivalent to the Puerco beds farther west Because the combined thickness of beds of Puerco and Torrejon lithology along the Rio Puerco is less than 100 feet thinner than the probable thickness of the Puerco and Torrejon formations on Arroyo Torrejon, it further appears that an equivalent of the Puerco formation may also be present along the Rio Puerco

PALEONTOLOGY —*Fossil Pinnotherids from the California Miocene* [1] MARY J RATHBUN, U S National Museum

Mr E W Galliher of the Hopkins Marine Station has sent to the National Museum a number of specimens of Pinnotherid crabs from the type locality of the Monterey formation at Pacific Grove, as follows

Specimens 1–5, from the top of hill with elevation of 610 feet about 1 mile W of N of Loma Alta and stratigraphically 700 feet approximately above the base of the type section of the Monterey formation

Specimens 6–9, 11, 12, from the top of Loma Alta (northerly peak) and stratigraphically about 1000–1300 feet above the base of the type section

The specimens are embedded in Monterey shale of a pinkish cream color The most abundant species, *Pinnixa galliheri*, varies in color from ochraceous buff to raw sienna *Parapinnixa miocenica*, from ecru drab to bistre, while the single specimen of *Pinnixa montereyensis* is mummy brown

Pinnixa galliheri, new species

Carapace in shape akin to *P faba*,[2] the anterior margin advanced at middle, lateral margins arcuate, continuous with the antero-lateral curve length a little more than 2/3 of width greatest width a little in advance of middle, surface finely and closely pitted or reticulate Gastric region defined mesogastric almost an equilateral triangle, a pit at each angle, a groove extending

[1] Published with the permission of the Secretary of the Smithsonian Institution. Received May 7, 1932

[2] M J RATHBUN *A recent species, Alaska to San Pedro California* Bull. U S Nat Mus, 97: 142, pl 31, figs 1–4, and synonymy 1918

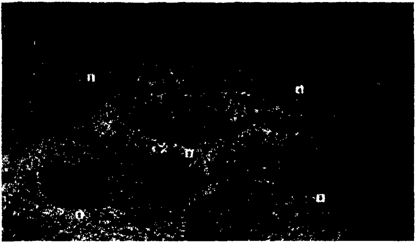

Fig. 1.—*Pinnixa galliheri*, No. 4, holotype, dorsal view showing half of outer surface, x 3. Fig. 2.—*Pinnixa galliheri*, No. 12, dorsal view for legs, x 3. Fig. 3.—*Pinnixa galliheri*, No. 11, ventral view for abdomen, x 3. Fig. 4.—*Pinnixa galliheri*, No. 6, ventral view for outline of carapace, x 3. Fig. 5.—*Pinnixa galliheri*, No. 5a, largest specimen, dorsal view, x 3.

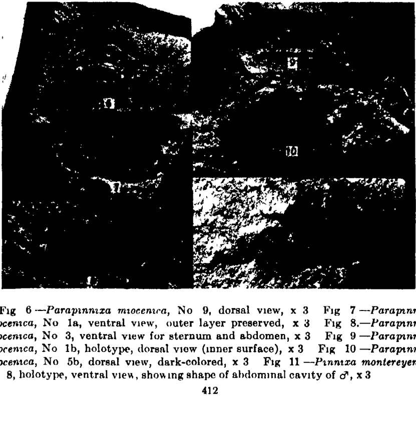

Fig. 6.—*Parapinnixa miocenica*, No. 9, dorsal view, x 3. Fig. 7.—*Parapinnixa miocenica*, No. 1a, ventral view, outer layer preserved, x 3. Fig. 8.—*Parapinnixa miocenica*, No. 3, ventral view for sternum and abdomen, x 3. Fig. 9.—*Parapinnixa miocenica*, No. 1b, holotype, dorsal view (inner surface), x 3. Fig. 10.—*Parapinnixa miocenica*, No. 5b, dorsal view, dark-colored, x 3. Fig. 11.—*Pinnixa montereyensis*, No. 8, holotype, ventral view, showing shape of abdominal cavity of ♂, x 3.

from its anterior end to the margin of the front. Cardiac region faintly outlined.

Chelipeds stouter than legs, fingers nearly as long as palms, upper margin of dactylus strongly curved. Ambulatory legs increasing in length from the first to the third, fourth leg much the smallest, meropodites narrow, the first one recurved, 5 times as long as wide, the second straight, equally wide, 6 times as long as wide, the third wider, nearly a fourth longer than the second, its length 4 4 times its greatest width, carpus-propodus as long as merus, propodus tapering distally Fourth leg very feeble, reaching if extended about to end of merus of third pair; carpus, propodus and dactylus subequal in length, dactylus with straight margins Sternum irregularly punctate Male abdomen gradually narrowing distally, terminal segment broadly rounded

Measurements—Length of carapace 7 8, width 11 8 mm

Specimens—Nos 2, 4 (holotype), 5*a*, 6, 7, 11, 12

Pinnixa montereyensis, new species

Only the ventral surface of the single specimen is exposed Carapace of ♂ narrow, approximately 8 mm long and 10 wide Posterior margin nearly straight, anterior and lateral borders forming a single arch Abdomen tapering gradually to the terminal segment where it widens, the segment having arcuate sides, projecting laterally and ending in a shallow median point, as in *P. transversalis*[3] Of the ambulatory legs, the third is longest, second next, first and fourth subequal, a terminal spine above on the merus of the first leg

Specimen—No 8, holotype

Parapinnixa miocenica, new species

General shape of carapace similar to that of the Recent *P nitida* (Lockington)[4] from the Gulf of California Carapace nearly twice as wide as long, widest in anterior half, anterior margin nearly transverse, antero-lateral angles broadly arcuate, surface, so far as exposed, very finely punctate, a deep pit at the posterior corners of the mesogastric region Chelipeds strong, carpus with arcuate outer line, movable finger longer than palm First ambulatory leg long and strong, merus widening from proximal to distal end, propodus diminishing gradually to distal end, about 2½ times as long on upper margin as its proximal width Male abdomen occupying ⅓ the width of proximal end of sternum and gradually tapering, tip unknown

Measurements—Estimated length of carapace 5 2, width 9 mm

Specimens—1*a*, 1*b* (holotype), 3, 5*b*, 9

[3] *op cit*, p 132, fig 76

[4] *op cit.*, p 108, fig 58a

PALEOBOTANY.—*Fossil stipules of Platanus.*[1] EDWARD W BERRY, Johns Hopkins University.

The presence of stipules in connection or association with fossil leaves is always an item of especial interest, since they are exceedingly rare as fossils. This is possibly due to the fact that so often they attain their best development on spring shoots which last are less

[1] Received June 2, 1932

likely to become fossilized than deciduous leaves. It might be expected that fugaceous stipules would frequently be preserved in spite of their sometimes delicate nature, and possibly many of not especially characteristic form have been passed by, but as a matter of fact very few have been recorded, and in many years experience in handling large quantities of fossil leaves I do not recall having found detached stipules except in the case of Salix[2] and the present instance.

Many years ago the late Lester F. Ward gathered together all of the references to stipular-like lobes or appendages in the genus Pla-

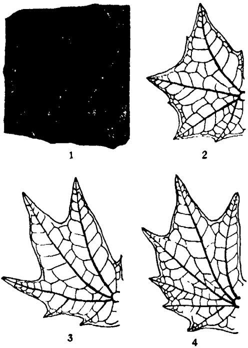

Fig 1—Fossil stipule in the genus Platanus, probably referable to *Platanus dissecta* Lesquereux Figs 2, 3, 4 —Examples of stipules of *Platanus occidentalis* Linné

tanus, and in several papers[3] advocated the idea that in this genus the modern type of stipules had been derived from ancestral basal lobes of the leaf lamina. None of Ward's examples are, however, like the modern type, such as is the specimen which is the subject of the present note.

[2] E W Berry U S Geol Survey Prof Paper 154: 242, pl 52, fig 6; pl. 64, fig 9 1929

[3] L F Ward U S Nat Mus Proc 11· 39–42, pl 17–22 1888, Am Nat, Sept 1890 797–810, pl 28

In earlier years I collected many specimens of *Platanus occidentalis* which illustrated Ward's hypothesis, and at that time made large collections which seemed to show a parallel ancestry for the stipules in the genus Liriodendron.[4] If this assumption is true, the origin of stipules in Liriodendron must have taken place during Upper Cretaceous time because what appear to be stipules of the normal modern type are found in the Atane beds of western Greenland [5,6]

The fossil Platanus stipule comes from the upper Miocene Latah formation outcropping in a cut of the S. P. & S Ry. at Spokane, Washington, and was collected by E. E. Alexander. It comprises the specimen shown in Figure 1 and a part of its counterpart, and may be described as follows. Reniform in general outline with five principal lobes, of which the uppermost is the largest. Lobes conical, pointed. Sinuses shallow, in no case extending as much as half way to the point of attachment, the two upper narrow, the two lower wide and scarcely perceptible. Margin with a few irregularly spaced tiny serrate teeth. Length about 4.25 centimeters Maximum width about 2 25 centimeters. Texture firm Veins well marked.

There are minor differences only between the fossil and some of the modern form of stipules in our common eastern *Platanus occidentalis*. Others have either less extended or more extended lobes. The venation of the fossil differs in but a single feature from that of the recent forms and this is that the midvein of the superior lobe is a branch of the midvein of the second lobe, a feature which I have not seen in modern stipules of Platanus although it may well occur in certain cases, and is a feature of no great significance in any event, as may be seen by the variation in the primary or secondary nature of the midveins of the inferior lobes

The normal stipules in both the California *Platanus racemosa* Nuttall and our eastern *Platanus occidentalis* Linné may be entire or dentate, and on especially vigorous shoots of saplings and from cut stumps are frequently as large or larger than the fossil. The modern, and presumably the fossil stipules, are normally united laterally to form a perfoliate affair attached by a basal tube which surrounds the shoot above the insertion of their respective leaves. Five or six of the principal veins extend in a parallel manner to the base of this tube. Rarely are the two members of a stipular pair exactly alike in outline, and one member of the pair is usually considerably smaller than the other.

[4] E. W Berry Bull Torrey Bot Club 28: Sept 1901.
[5] O Heer Fl. Foss Arct 6: part 2 90, pl 23, fig 8 1882
[6] E W Berry Torreya 3: 129, fig 4 1903

The question of the particular leaf species to which the fossil stipule belongs can be settled with some degree of certainty. Three nominal species of Platanus have been recorded from the Latah formation. These are the common and widespread *Platanus dissecta* Lesquereux, the somewhat protean *Platanus aspera* Newberry, and *Platanus appendiculata* Lesquereux. The last is of somewhat doubtful identity in the Latah and was based upon a single incomplete specimen with a perfoliate basal lobe. The present fossil stipule could not possibly have belonged to *Platanus appendiculata* unless it is conceded that it had both basal lobes and normal stipules at the base of the petiole, which is possible but not probable. The character of the dentition of the fossil stipule would seem to me to exclude *Platanus aspera* from consideration, thus leaving *Platanus dissecta*, which is the commonest Miocene and the commonest Latah species, as the probable parent

I have seen no modern stipule precisely like the fossil, but have figured three stipules of *Platanus occidentalis* and it will be seen that, although not identical, there is much less difference between the fossil stipule and Figure 2 of *occidentalis* than there is between Figure 2 and the extreme dentate forms of *occidentalis* shown in Figures 3 and 4. It is at least clear that the modern type of stipule in this genus was in existence as early as the late Miocene, and that the stipules have undergone but slight and certainly no essential change since Miocene time.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY

487TH MEETING

The 487th meeting was held at the Cosmos Club, March 9, 1932, President F. E. MATTHES presiding.

Program G F LOUGHLIN. *The results of recent geologic work at Cripple Creek, Colorado* —The speaker confined his remarks mainly to the structural development of the denuded Cripple Creek volcano, which was formed by the explosive eruption of phonolitic and related material through pre-Cambrian granites, schist, and gneiss The principal causal factors were the settling of the fragmental material in the crater and intermittent regional compression. Settling was first illustrated by the local explosion pipe known as the Cresson "blowout," which has an elliptical form and tapers downward into two "roots" that have an easterly alignment.

The main crater was developed along a complex network of fissure zones, the principal one trending east and southeast Exposures in the deeper mine workings show that it also tapers downward with increasingly elongate form and probably separates into several roots. Settling developed steeply dipping fissure systems normal and parallel to the walls of the elongate parts, and also

gently dipping fissures or "flats" Regional compression developed minor shear zones in and around the volcanic mass, many of which coincided in the general direction with the fissures due to settling The more profound of these shear zones determined the courses of dikes and ore deposits, which, especially in the shallower part of the mass, spread along the "flats" (*Author's abstract.*)

Discussed by Mr. L. H SMITH.

SIDNEY PAIGE *The origin of the Vredefort dome* —In a recent publication[1] Hall and Mollengraaff describe and discuss a remarkable, perhaps unique, geologic structure The Vredefort granite, a circular mass about 40 kilometers in diameter is surrounded by a girdle of *overturned, metamorphosed,* sedimentary and igneous rocks. The inversion of the sediments involves not less than 10,000 meters of strata and the metamorphism affects in places as much as 3000 meters of strata Basic rocks invade the peripheral sediments in sill-like masses and also are found cutting the granite parallel to the contact and in places normal to it

The authors conclude that the Vredefort granite is not intrusive into the sediments that surround it, but is the ancient floor upon which the sediments were laid down, and that the structure as observed today is due to *centripetal pressure* the nature and cause of which is frankly admitted to be unexplained The authors are the first to admit that many facts of observation are open to divergent interpretations There are many such aspects of the problem that cannot be discussed here, or even mentioned, but are apparent on a careful study of the monograph and which the writer hopes to consider at another time

The writer believes that the facts presented by Hall and Mollengraaff support the following thesis —(1) That the ancient floor of granite and schist upon which the Witwatersrand beds were laid down was invaded by a later granite; that the invaded floor was heated to a point where plasticity prevailed and the invaded floor and the invading granite acted essentially as a relatively stiff magma, that the circularity of the intrusion was due to this fact alone, that the vertical upward movement of the re-melted, invaded, floor created a great *distensional* dome, that continued upward movement brought about faulting at a late stage, along radii of the dome in the zone of fracture and that ultimately these faults extended to the base of the sedimentary column, that low angle concentric shears developed, that in view of these structures the magma collapsed laterally which was the direct cause of the overturned structures observed today (2) That the Vredefort domical structure is but one of a number of anticlinal structures, viz,—the Johannesburgh, Ventersdoorp and Heidleberg anticlines, all *causally related*; that the related anticlines are equally due to forces acting vertically upward, and producing *distension* of the crust, and that the lack of overturning except at Vredefort is to be explained by the fact that at other places the basement floors were not invaded or re-heated to any substantial degree, that the motivating force of all these uplifts was *isostatically* related to the enormous downwarp of the Bushveldt complex, immediately to the north, that the broad picture suggests that an immense crustal downwarp in one area resulted in subterranean transfers of material, re-heating of an ancient basement, invasion of the basement, distension of the crust by vertical uplift on a grand scale, with local violent

[1] HALL, A L, and MOLLENGRAAFF *The Vredefort Mountain Land in the Southern vaal and the Northern Orange Free State* Ver K Akad van Wetenschappen Amsterdam (Tweede Sectie) Deel **24** No 3 1925

compression of a thick series of sedimentary rocks owing to their displacement by an essentially igneous mass. (*Author's abstract.*)

Discussed by Messrs. JOHNSTON and RUBEY.

D F HEWETT: *The habitat of manganese minerals.*

Discussed by Messrs HESS, L H. SMITH, LOUGHLIN, C S. ROSS, and SCHAIRER

488TH MEETING

The 488th meeting was held at the Cosmos Club, March 23, 1932, President F E MATTHES presiding

Informal communications Mr F. L. HESS described the occurrence of hydrocarbons in samples of pegmatites from Parry Sound, Ontario, Canada. The partly dried oil or hydrocarbon occurred in cracks in feldspar crystals and some of the globules bore minute crystals of pyrite and quartz A much harder hydrocarbon, nearly pure carbon, called thucholite appears to have replaced uraninite

P F SHENON described some platinum placer concentrates from Waldo, Oregon which contained small rings These rings proved upon spectral analyses to be fragments of tungsten filaments from electric light bulbs

W D JOHNSTON, JR showed tables and graphs of geothermal data and the adjusted geothermal gradient of Grass Valley, Cal He compared this gradient with that observed in other deep mines

Discussed by G S RICE and W H BRADLEY.

H. S LADD. *The Melanesian Continent*—The hundreds of islands which are concentrated in the southwest quarter of the Pacific Ocean may be divided into two groups, the oceanic and the continental. The latter, showing plutonic and metamorphic rocks in addition to the volcanic rocks and limestone which characterize the oceanic islands, all lie within a line drawn from Yap southeastward through Turk, New Ireland, the Solomon Islands, and Fiji to Tonga, thence southwestward through the Kermadecs to include New Zealand and certain of its outlying islands. Fossiliferous Paleozoic and Mesozoic rocks have a wide and somewhat systematic distribution within the area thus outlined, indicating that large parts of it have been above the ocean depths for much of geologic time.

The distribution of the arcs and fore-deeps suggests that this area, whose boundaries roughly coincide with those of Melanesia, was built up originally as a series of folded mountains There is much evidence however, particularly from Fiji, Tonga, and New Zealand, to support the hypothesis that block faulting, with the extrusion of volcanic material along some of the major fault planes, was initiated prior to the Miocene and is largely responsible for the present distribution of land and sea. (*Author's abstract.*)

Discussed by Mr MATTHES.

C W. WRIGHT: *The 1931 Glacier Bay expedition*—The writer showed the present positions of the glaciers and extent of the ice cap within the Glacier Bay region, S E Alaska, and also the outline of the ice field at the time he and his brother, F. E Wright, mapped the area 25 years ago The tidewater glaciers have all receded, some of them several miles up the inlets, and certain of those that were at tidewater in 1906 are now a mile or more back on the land, due in part to the recession but largely to the advancing delta deposits. At the Rendu Glacier, with a drainage area of 30 square miles, it was estimated that 70 million cubic feet of material are being deposited at the delta each year, which has advanced over 3,300 feet in 25 years.

It was also estimated that the rate of ablation of the entire Glacier Bay ice cap, covering 500 square miles, has averaged from 20 to 25 feet per year more than the snow fall. During the past 25 years the ice plateaus, the surface of which was at 1,000 to 1,200 feet altitude, are now but 500 feet above sea level, and many of them will be gone within a decade or two owing to the more rapid rate of melting at the lower levels

The discovery of two buried forests at different levels in the same gravel bank and another at tidewater with tree trunks rooted in undisturbed beds of top soil indicates definitely that there have been several periods when the Glacier Bay area was covered with luxuriant forests In view of these facts, the writer referred to the reason for the present recession and past advances of the Glacier Bay ice cap as a fight for supremacy between the sun rays, which are melting down the surface of the ice, and the snow fall, which is responsible for its existence.

Glacier Bay borders the Pacific Ocean where the storms come from the south and southwest As the area of perpetual snow is diminishing within the Glacier Bay area, the cold atmospheric conditions necessary for abundant snow fall are therefore lessening, and many of the storm clouds now pass over the Glacier Bay area and precipitate their moisture along the coast range 150 miles to the southeast where the areas of perpetual snow are increasing in size and colder atmospheric conditions prevail That this is so is evident from the advance of the Taku, a Coast Range glacier, the face of which during the past 25 years has pushed forward about two miles, a half-mile of which has been added during the past two years

Other causes such as the earthquake in 1899 and the effect of the Japan current and the local high tides have aided somewhat the recession in Glacier Bay, but these affect only a small portion of the ice cap fringe and the main cause of recession must be the sun rays which attack the entire surface

The reasons for the several changes from the long periods of recession extending over several centuries to even longer periods of advance are not so clear. The recession usually continues until the glaciers have receded far up the mountain valleys and the exposed land areas have been overgrown by dense forests These forests may have had their effect in helping to retain and protect the snow fall from the sun's rays at the lower elevations, thus giving a chance for the area of perpetual snow to increase, and gradually to alter the local atmospheric conditions so as to encourage more abundant snow fall and thus start a new cycle of glacial advance The writer does not believe that the ice recession in Glacier Bay is connected with any general climatic cycle but that it is a local phenomenon recurring every few thousand years due to changes in local atmospheric conditions (*Author's abstract*)

HARRY FIELDING REID. *Glacier Bay 40 years ago*—The speaker showed lantern slides of the glaciers of Glacier Bay in 1890 and 1892 and contrasted them with others made last summer. They showed enormous changes, three of them, the Muir, the Grand Pacific, and the Johns Hopkins having retreated about ten miles. The many old forests buried under thick deposits of gravels show that at no very long time ago the glaciers were markedly smaller than they are now, and that the great advance of 150 years ago was of short duration. (*Author's abstract*)

MR. WRIGHT'S and MR. REID'S papers were discussed together by Messrs. W O. FIELD, BURCHARD, CAPPS, COTTSWORTH, and MATTHES

J. F. SCHAIRER and W. H. BRADLEY, *Secretaries*.

SCIENTIFIC NOTES AND NEWS

Under the provisions of the Economy Act, E. O. ULRICH, M. R. CAMPBELL, and F. C. SCHRADER of the Geological Survey were retired June 30.

By order of the President the following members of the Academy are exempted from the retirement provisions of the Act: WALTER HOUGH, National Museum, WILLIAM J HUMPHREYS, Weather Bureau; CHARLES F. MARVIN, Weather Bureau, TIMOTHY W. STANTON, Geological Survey (temporary extension); LEONARD STEJNEGER, National Museum; C. DAVID WHITE, Geological Survey

Obituary

Dr GEORGE K BURGESS, director of the Bureau of Standards, past president of the Washington Academy of Sciences, died of cerebral hemorrhage on July 2, 1932 He was born in Newton, Mass , Jan. 4, 1874. After graduating from the Massachusetts Institute of Technology, he studied at the Sorbonne in Paris. There he redetermined the value of the Newtonian constant of gravitation, receiving his doctorate in 1901 with highest honors. Dr. BURGESS entered the Bureau of Standards in 1903 and by his ability and application advanced steadily from assistant physicist to director of the Bureau His first work was in the field of pyrometry. In 1913 he become chief of the metallurgical division He was appointed director on April 21, 1923.

Dr BURGESS was chairman of the National Research Council, a member of the National Advisory Committee for Aeronautics, of the National Academy of Sciences and of the Washington Academy of Sciences He was the United States delegate to the seventh International Conference on Weights and Measures in Paris in 1927 and to the world Engineering Congress in Tokio in 1929, president of the National Conference on Weights and Measures; member of the Foreign Service and Engineering Commissions, director of the American Standards Association, honorary member of the American Foundrymen's Association; member of the American Institute of Mining and Metallurgic Engineers, past president of the American Society of Steel Treating, and the American Society for Testing Materials, member of the American Commission on the Annual Tables of Physical and Chemical Constants; member of the Optical Society of America, the American Physical Society, Philosophical Society of Washington, and the American Institute of Metals; fellow of the American Association for the Advancement of Science, honorary member of the Japanese Society of Mechanical Engineers, chairman of the Federal Specifications Board, the National Screw Thread Commission, and the Federal Fire Council.

DR CHARLES WALLACE RICHMOND, associate curator of birds, U. S. National Museum, died in Washington May 19, 1932. Dr. RICHMOND was born in Kenosha, Wisconsin, Dec 31, 1868 He became a page in the House of Representatives in 1881, joined the Geological Survey in exploration in Montana in 1888, and became ornithological clerk in the division of economic ornithology and mammalogy in the Department of Agriculture on his return. In 1894 he was appointed assistant curator of birds at the U. S. National Museum and in 1918 associate curator. He was a recognized authority on problems of ornithology

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BOTANY.—*A species of* Pythiogeton *isolated from decaying leaf-sheaths of the common cat-tail.*[1] CHARLES DRECHSLER, Bureau of Plant Industry.

Late in October 1931, some specimens of the common cat-tail (*Typha latifolia* L.) collected in marshes near Port Clinton, Ohio, were submitted to me as being illustrative of a disease through which the cat-tail stands in that neighborhood had been damaged so severely that the loss of thousands of muskrats from lack of winter food was being anticipated. The trouble affecting the plants was apparently of the type usually referred to as foot-rot, being evidenced in every case chiefly in extensive watersoaking, brownish discoloration and eventual decay of the basal portions of the fleshy clasping leaf-sheaths. An assortment of fungi, including nearly a dozen species of *Pythium*, were isolated from the affected tissues. Among these, a certain form very similar to the one previously described by me (12) as *Pythium helicoides*, if, indeed, not identical with it, made its appearance especially frequently, thereby suggesting that the similarity of the injury to that which I have frequently observed in Wisconsin on leaves and petioles of the white water-lilies (*Nymphaea odorata* Ait and *N. tuberosa* Paine) attacked by an undoubted member of the *helicoides* series, may perhaps not be altogether accidental Any more definite opinion as to parasitic relationships will require specimens of diseased cat-tails collected, needless to say, earlier in the season, showing fresh lesions on vegetatively vigorous plants. In the meantime, it may not be inappropriate to direct attention to another fungus in the assortment of pure cultures obtained, because of interest attaching to it as a member of probably the most critical genus in the Pythiaceae.

The genus in question is *Pythiogeton*, erected by von Minden (20) in 1916 to include three aquatic fungi growing on submerged decaying

[1] Received June 6, 1932.

plant substrata, and described by him as *Pythiogeton utriforme*, *Pythiogeton transversum* and *Pythiogeton ramosum*, the last-mentioned being regarded by its author as of somewhat doubtful independence. A feature common to all of these forms was the production of a characteristically elongated utriform sporangium attached at its upper end to the supporting hypha, its axis therefore not coinciding with but rather directed transversely to that of the latter. In spite of its obviously striking aspect, von Minden did not consider the asymmetrical sporangium as in itself making necessary a genus distinct from *Pythium*, for, as he soundly reasoned, not only were subspherical sporangia and sporangia intermediate in shape between the subspherical and utriform types present in his fungi, but the genus *Pythium* already embraced a variety of sporangial types to which another might be added without much violence At the time rather little was known concerning the occurrence of lobulate sporangia in *Pythium*, so that grounds were then lacking for an obvious but evidently somewhat specious analogy that might later have suggested itself between the utriform sporangia on the one hand and the individual digitate swollen sporangial elements of such forms as *Pythium arrhenomanes* Drechsl. in which these elements often attain comparable, if not equal dimensions, on the other A most distinctive feature of *Pythiogeton* von Minden recognized in the sequence of events intimately related to the production of zoospores the discharge of the sporangial contents through an evacuation tube into a tubular or elongated vesicle, the accumulation of these contents in the distal portion of the vesicle, the disintegration of the vesicle membrane, and the subsequent fashioning of the zoospores from the protoplasmic mass, now naked and directly in contact with the surrounding water Although von Minden did not succeed in isolating and cultivating in pure culture any of the three species of *Pythiogeton* described by him, he was able with some degree of certainty to relate sexual structures to *Pythiogeton utriforme* and *Pythiogeton transversum* The extraordinary thickness of oospore wall shown by him in his figures of both these species is assuredly absent from any species of *Pythium* hitherto described, as is also the polygonal shape of the mature oogonium depicted by him for *Pythiogeton transversum*. Among additional features mentioned by von Minden as setting *Pythiogeton* apart from *Pythium*, were the occurrence of a long evacuation tube; the helicoid involvement of the hypha supporting one sexual organ by the hypha bearing the other, present in *Pythiogeton transversum*, and the absence in *Pythiogeton utriforme*, at least, of any contraction of the oogonial contents preliminary to the formation of the oospore wall.

Except for the recent citation by Ito and Nagai (15) of *Pythiogeton ramosum* among the fungi isolated by them from rice seeds and rice seedlings in Japan, and a brief discussion by Sparrow (23) of a fungus which he found in three localities in North America and identified likewise as *Pythiogeton ramosum*, the literature since the appearance of von Minden's paper seems to present no first-hand information concerning any member of the genus under consideration In various general accounts dealing at second hand with the taxonomy of the Phycomycetes, *Pythiogeton* has been adopted as a valid genus distinct from *Pythium*, though the grounds for the distinction have not always been those which von Minden apparently considered most decisive. Meanwhile additional information concerning many species of *Pythium* then known has come to light, and a considerable number of new species have been described, so that the meaning of the latter genus has in some respects been modified or extended. In a treatment of the species of *Pythiogeton* isolated from the common cat-tail, some consideration may therefore well be given to the more recent changes in our understanding of allied genera.

In his discussion of the taxonomic position of *Pythiogeton*, von Minden stated that his species showed similarity to *Pythium* in the development and vegetative habit of their mycelia As this investigator was working entirely with water cultures, it may be inferred that his comparison applies primarily to the extramatrical submersed portions of mycelium that can be readily taken up from such cultures and conveniently examined. When cultivated in liquid media, as, for example, decoctions of lima beans, of maize meal, or of yeast, the fungus isolated from leaves of cat-tail likewise shows a general similarity to the more delicate species of *Pythium*, the wider and longer axial hyphae being nearly straight or smoothly fluxuous in course, the shorter lateral branches borne on them being of more irregular course and giving off at much shorter intervals, branches of inferior lengths. As among species of *Pythium*, each of the hyphal elements in the actively growing portions of mycelium, appears usually, though not constantly, to be smaller in diameter than the element from which it originates, the diameter at the base being, however, sustained well toward the termination with scarcely any diminution. Perhaps the branches are rather more frequently inserted at angles approaching a right angle than in most species of *Pythium*, among which a more forward orientation is usually apparent, yet the difference is certainly not very marked when some of the more exceptional members of the latter genus are considered. With respect to the contents of the

mycelium, a general similarity with species of *Pythium* is again evident, the protoplasmic material here also showing a condition median between the rather diaphanous, sappy composition apparent in species of *Aphanomyces* and the very substantial densely granular composition common to species of *Phytophthora*.

When the fungus under consideration is grown on soft artificial gel substrata, such as can be prepared by adding to suitable decoctions agar-agar in the proportion of one part in a hundred, the vegetative habit is not markedly different from that resulting from growth in a liquid medium. Appressoria in the form of terminal clavate distensions, and very similar therefore to those produced by many species of *Pythium,* make their appearance in large numbers on surfaces where the mycelium comes in contact with a solid body, as, for example, on the under side of a petri-dish culture (Fig 1, A, Fig. 2, G). However on harder agar media containing two parts of agar-agar in a hundred, the hyphae frequently show a somewhat moniliform shape with expansions and constrictions succeeding each other at short intervals. Appressoria are less definitely differentiated, possibly for the reason that the expansions in themselves may represent modifications in the nature of appressoria, perhaps enabling the filaments to thrust their way through substrata too resistant for filaments of more uniform width. Because of its reduced luxuriance, growth on the harder and drier media presents a characteristic frail appearance, which is borne out also by the meager aerial mycelium present usually as a very scanty arachnoid fleece overlying the surface of the substratum and extending up the wall of the container for distances of 5 to 10 mm or more. A somewhat increased development of aerial mycelium has often been noted when the fungus was grown in mixed culture with a species of *Alternaria* congenial to it, provisionally identified as *A. tenuis* Nees, the increase being attributable apparently to the constant presence of minute droplets of water supplied through guttation by the intermixed organism. In actively growing condition, the mycelium, like that of Phycomycetes generally, is continuous, septa, of course, later making their appearance with the progressive evacuation of protoplasmic contents, to set off living from emptied portions, so that in the end cross-walls are usually present in moderate abundance.

Similarities in mycelial habit between the fungus under consideration and the more delicate of the fungi assignable to *Pythium,* as, for example, *Pythium acanthicum* Drechsl. are thus fairly obvious Yet the general aspect of the former, at least under some conditions of growth, impresses one as being alien to *Pythium,* though it must be

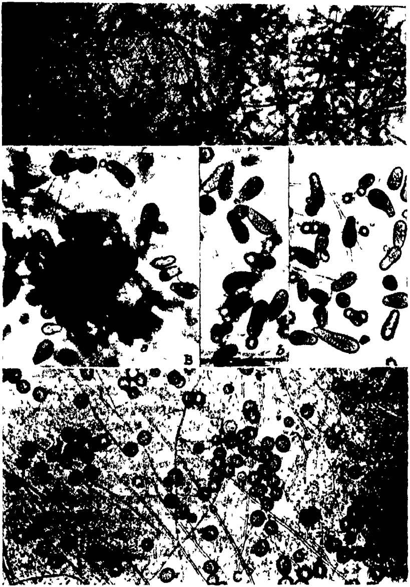

FIG. 1.—*Pythiogeton autossytum*, x 91. A.—Vegetative mycelium bearing numerous appressoria. B.—Temporary bursiform sporangia borne on irrigated mycelium, some, *a*, being clustered in a dense, almost opaque mass, and others, *b*, being found in open arrangement. C.—Subspherical sporangia produced in string-bean agar. Photographed by Marguerite S. Wilcox.

admitted that the latter genus is not characterized by a degree of uniformity in mycelial habit such as prevails in more closely integrated genera like *Phytophthora* or *Aphanomyces*, the family resemblance in certain of the more aberrant types referable to it, often being not immediately obvious. As might be expected the American fungus exhibits a manner of branching unmistakably similar to that expressed in von Minden's figures of *Pythiogeton utriforme*, *Pythiogeton transversum* and *Pythiogeton ramosum* Some doubt, however, attaches to the relative coarseness of the several plants Von Minden's values for the diameter of the hyphae of *Pythiogeton utriforme*, 2.5 to 3.5μ, which it is to be inferred hold for *Pythiogeton transversum* and also for the vegetative filaments of *Pythiogeton ramosum*, might be interpreted as indicating a generally more delicate mycelium than that of the fungus isolated from decaying cat-tail tissues, with living hyphae measuring up to 7μ in diameter Indeed, a specific difference may actually be present here Yet it must be considered that von Minden's measurements were in all probability carried out mainly on extramatrical hyphae immersed in water containing practically no nutriment, rather than on filaments developed within a solid substratum or in a liquid pabulum Butler's (7) figures of his *Pythium diacarpum* suggest that similar conditions may have had their effect in the production of the unusually slender extramatrical hyphae described for that fungus, even though growth characteristics inherent in the species are to be given primary importance

When a vigorously growing mycelium of the species of *Pythiogeton* from Ohio is transferred to distilled water, production of temporary sporangia usually begins within a day, and in the course of an additional day or two results in a very copious display of these bodies (Fig 1, B, Fig 2, A-F) Many of the sporangia are borne in the manner held typical by von Minden for his *Pythiogeton transversum*, that is, they arise as intercalary structures a short distance from the end of the supporting filament On attaining definitive size such sporangia are delimited by the insertion of two septa, so that the distal portion of filament, from which the protoplasmic contents have in most cases been withdrawn earlier, appears finally as an empty appendage. As in *Pythiogeton transversum*, this appendage is of variable length, but on the whole would seem considerably shorter than the appendages shown in von Minden's illustrations. In other cases the sporangium is intercalary, but remote from the tip of the supporting hypha, so that after the appearance of the delimiting septa, it lies between two elements of which both are filled with protoplasm. In

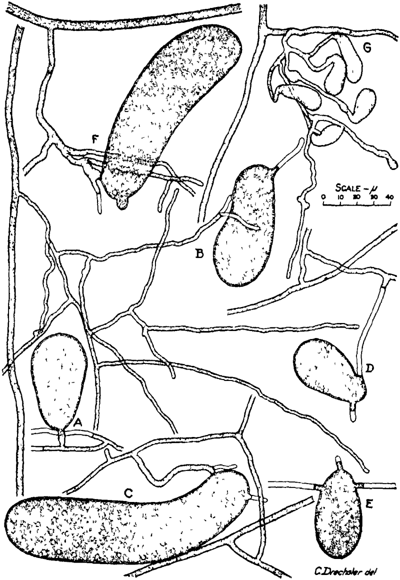

FIG 2 —*Pythiogeton autossytum*, drawn with aid of the camera lucida, x 460 A-F — Temporary bursiform sporangia showing differences in shape and in relationship to mycelium F—A group of appressoria formed in contact with the base of a petri dish containing an agar plate culture

some instances of this kind the sporangium may nevertheless bear the usual short appendage (Fig. 2, F), which evidently must have originated earlier as a short branch of the parent filament.

The various intercalary relationships mentioned may be made out most frequently when the sporangia are not of the largest and when optical conditions are especially favorable. In more luxuriant preparations several days after transfer to water, when temporary sporangia of greater dimensions are present in abundance, a terminal attachment of these structures, corresponding to the type of attachment von Minden described as distinctive for *Pythiogeton transversum*, is much more frequently apparent than an intercalary relationship. It may be suspected, however, that optical difficulties arising from the thickness of such luxuriant mycelial mats, and from poor visibility of the short, empty appendages when not seen attached in profile and after exposure to increasing action of contaminating bacteria, have a considerable part in bringing about this effect.

As in the congeneric forms described by von Minden, the temporary sporangium of the American fungus is typically a body that in its shape and its mycelial relationship may be compared to an elongated pouch usually somewhat wider below than at its upper end, at which latter it is attached in such manner that its free lower part is directed at an oblique or a right angle to the axis of the supporting stalk. Variations of different sorts are usually abundantly represented Through shortening of the bursiform structure along its own axis, a merely ventricose shape may result (Fig 3, A). In preparations very favorable for the production of sporangia, two bursiform parts are often fused into a single large bilobate reproductive body (Fig. 4, L, Fig 5, A) And at least occasionally an elongated terminal sporangium may be borne with its axis coinciding with that of the supporting filament (Fig 2, A), so that a symmetrical relationship approximating that found in various species of *Pythium* is brought about.

With respect to size the temporary sporangia show a relatively high degree of variability. As might be expected, the vigor and the mass of the mycelium employed as well as such environmental factors as temperature and freedom from food materials, are reflected in the dimensions and number of these structures. Older preparations in which the mycelium has been in large measure exhausted are apt to show an increasing proportion of smaller sporangia. Frequently improper irrigation or excessive development of some contaminating organisms appears to encourage the production in large numbers of

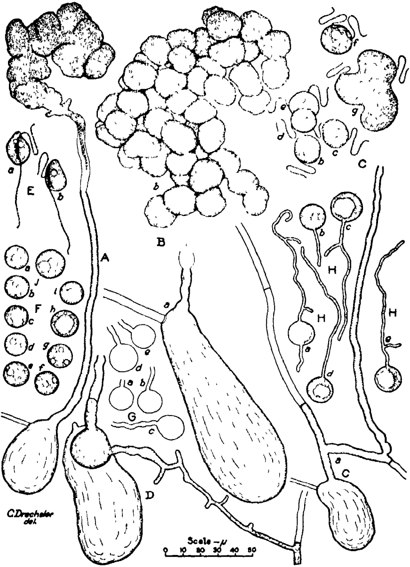

Fig 3.—*Pythiogeton autossytum*, drawn with aid of the camera lucida x 400. A.—A bursiform sporangium immediately after discharge of contents. B.—A submerged bursiform sporangium together with its discharged contents, 10 minutes after dehiscence. C.—A bursiform sporangium, *a*, with discharged contents in a later stage of zoospore development, being present partly as individualized spores, *b-f*, almost already to swim away, and partly as a mass, *g*, provided with some cilia but still without definite cleavage. D.—An empty sporangial envelope and a second sporangium developing within it. E, *a-b*.—Motile zoospores. F, *a-j*.—Zoospores after rounding up. G, *a-e*.—Empty zoospore envelopes each with open evacuation tube, evidencing repetitional development. H, *a-e*.—Zoospores germinating by one or more germ tubes.

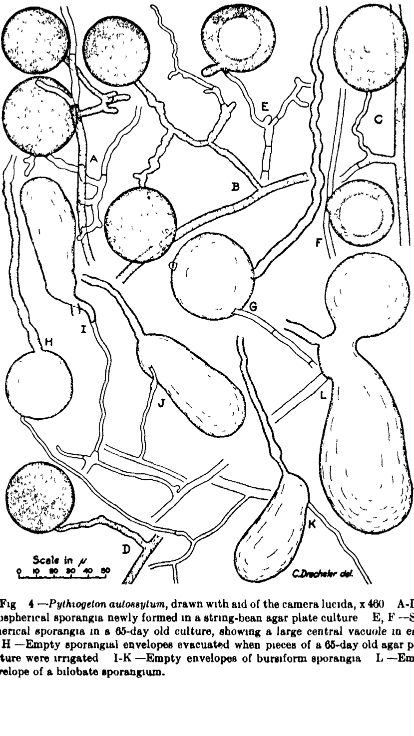

Fig 4 —*Pythiogeton autossytum*, drawn with aid of the camera lucida, x 460 A-D — Subspherical sporangia newly formed in a string-bean agar plate culture E, F —Subspherical sporangia in a 65-day old culture, showing a large central vacuole in each G, H —Empty sporangial envelopes evacuated when pieces of a 65-day old agar plate culture were irrigated I-K —Empty envelopes of bursiform sporangia L —Empty envelope of a bilobate sporangium.

intergrades between typical temporary sporangia and typical resting sporangia As neither the undersized nor the intergrading bodies attain to proportionately great numbers until several days after vigorous mycelia have been transferred to water, the sporangia already present in impressive abundance during the period from the thirty-sixth to the fourth-eighth hour after such transfer provide an exhibit perhaps as representative of the morphology of the species as any that could be selected. Using material of this description measurements of 100 sporangia chosen at random (25 being thus chosen in each of four separate preparations) yielded values for length distributable in groups covering ranges of 10μ as follows 31–40μ, 2, 41–50μ, 1, 51–60μ, 6, 61–70μ, 3, 71–80μ, 19, 81–90μ, 16, 91–100μ, 17, 101–110μ, 15, 111–120μ, 9; 121–130μ, 6, 151–160μ, 3, 161–170μ, 1; 171–180μ, 1, 181–190μ, 1. The same sporangia gave measurements for greatest diameter with the following frequency distribution. 21μ, 1, 24μ, 1; 25μ, 1, 29μ, 2, 30μ, 1, 31μ, 4, 32μ, 4, 33μ, 3, 34μ, 2; 35μ, 2, 36μ, 4; 37μ, 4, 38μ, 3, 39μ, 6, 40μ, 5, 41μ, 5, 42μ, 5, 43μ, 6, 44μ, 5, 45μ, 5, 46μ, 1, 47μ, 3, 48μ, 6, 49μ, 5, 50μ, 2, 51μ, 1, 52μ, 3, 53μ, 2, 54μ, 4; 55μ, 1, 58μ, 1, 59μ, 1, 62μ, 1. From the two sets of values averages of 96μ and of 42μ were computed for length of temporary sporangium and greatest diameter of temporary sporangium respectively. It may hardly be necessary to state that more extreme dimensions than those encountered among the 100 structures chosen at random, came under observation. Thus the empty sporangium shown in Figure 5, G, which it may be presumed gave rise to only a single zoospore, was found to measure 16μ in length and 13μ in diameter The broadest temporary sporangium seen was found to measure 68μ in diameter at its widest zone, while the longest sporangium encountered, the bilobate specimen shown in Figure 5, A, measured 226μ along its curved longitudinal axis Even without attributing excessive importance to such more extreme expressions of size, the temporary sporangia manifestly do not show sufficient uniformity with respect to dimensions or shape to justify much elaboration of metric data. Yet on the other hand the greatest values obtained for length and diameter are so much smaller than the corresponding values given by von Minden for the largest of only four sporangia of *Pythiogeton transversum*, chosen by him apparently at random, namely 299μ and 79μ respectively, that identity of the two forms would seem rather definitely out of question. For reasons of taxonomy it is to be regretted that von Minden did not give measurements, however approximate, of the sporangia of *Pythiogeton utriforme* and *Pythiogeton ramosum*, nor any statement as to the

dimensional ranges represented in them in comparison with those of *Pythiogeton transversum*. Such measurements, it is true, have been supplied by Sparrow for the form which he identified as *Pythiogeton ramosum*. In view of the very unhappy status of many of the composite specific characterizations to be encountered in mycological literature, more particularly in the literature concerning the submerse and amphibious Phycomycetes, it might, however, be well not to combine Sparrow's measurements with the descriptive details given by von Minden until further information favoring combination is brought to light

At the time the sporangia of *Pythiogeton* attain full size, their contents appear to consist of densely granular material with some vacuoles, mostly rather small and inconspicuous, interspersed here and there. The development leading to the production of zoospores, entails a reorganization with the result that during somewhat later stages vacuoles of variable sizes are no longer much in evidence, but instead the densely granular material reveals imbedded in it structures measuring nearly uniformly about 2μ or slightly more across that give the impression of being more refractive than ordinary vacuoles The number of these structures present is proportional to the size of the reproductive body, the smaller sporangia containing often less than a dozen, whereas the largest ones contain a hundred or even more. They show some correspondence in size, number and distribution to the nuclei as made visible in material stained with Delafield's haematoxylin, though this correspondence may be altogether fortuitous, and lacking in significance. The assertion of identity here would in any case encounter the same sort of difficulty as the identification of the refringent body (the "helle Fleck" of DeBary) in the living mature oospore of species of *Pythium*, with the single large oospore nucleus appearing in stained material—an identification suggested by the findings of Trow (24) on *Pythium ultimum* Trow, and of Edson (14) on *Pythium aphanidermatum* (Eds.) Fitzp., even though these findings took apparently no cognizance of DeBary's (2, 4) remarks on the prevalence of the "helle Fleck" as a morphological feature. Whatever may be the explanation of the characteristic lacunulose appearance, this appearance at about the time the evacuation tube is being put forth, yields to one marked by the coalescence of increasingly extensive longitudinally elongated vacuoles. The ensuing vacuolization, if on the whole somewhat less extensive than that occurring in sporangia of species of *Pythium* preparatory to dehiscence, nevertheless takes

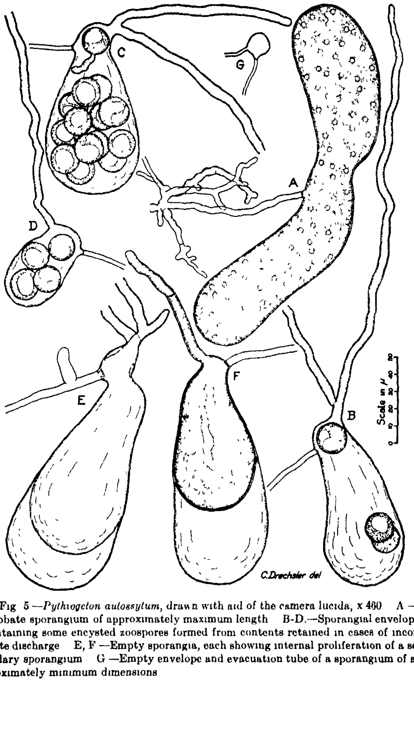

FIG 5.—*Pythiogeton autossytum*, drawn with aid of the camera lucida, x 460 A.—A bilobate sporangium of approximately maximum length B-D.—Sporangial envelopes containing some encysted zoospores formed from contents retained in cases of incomplete discharge E, F.—Empty sporangia, each showing internal proliferation of a secondary sporangium G.—Empty envelope and evacuation tube of a sporangium of approximately minimum dimensions

very much the same course, and would seem to be representative of quite similar development.

While protoplasmic reorganization is thus being effected, the evacuation tube reaches definitive length and develops at its apex a hyaline cap of the same sort as that regularly found throughout the genus *Pythium*. The distal portion of the tube is without marked modification below the hyaline cap, not being expanded as, for example, in the form which evidently DeBary (2) and after him Ward (27) discussed under the name *Pythium gracile*, and for which the binomial *Pythium complens* Fisch. is probably more appropriate than any other. When the hyaline cap yields the sporangial contents stream out with great rapidity, and collect, as von Minden so well described, in an irregularly elongated mass in front of the orifice. In the fungus under consideration the mass of discharged protoplasm was not frequently seen to be protruded as directly forward as von Minden's figures indicate, but very generally was observed to be folded, buckled or compressed into a bizarre shape (Fig. 3, A), the irregularity of which became more pronounced as the amount of material concerned became larger. In at least those instances in which the extruded mass is submerged in water, further development proceeds in the manner set forth by von Minden. The vesicle wall derived from the inflation of the hyaline cap soon disintegrates except often for a more persistent tubular proximal part, corresponding evidently to the urn-shaped structure described by Butler for his *Pythium diacarpum*, which may sometimes be made out several hours or even a day later as a diaphanous extension of the empty evacuation tube The naked mass thus exposed directly to the water very soon reveals cleavage furrows, and in about 10 minutes is converted into an aggregation of fairly well separated individual portions (Fig. 3, B). In the course of about 15 or 20 additional minutes, these portions develop cilia that become increasingly active (Fig. 3, C, *b-f*), until finally the separate protoplasts swim away as motile zoospores.

The fully fashioned zoospore (Fig. 3, E) is of the shape usually designated as reniform. its length exceeds its width by about one-half, the forward end is somewhat pointed, the rear broadly rounded, and the side bearing the well defined longitudinal groove in which the cilia have their origin is noticeably flattened, the thickness measured in a plane from grooved to opposite side being somewhat smaller than the width measured at right angles to this plane. Of the two cilia the anterior one seems the more active, as the posterior organ can sometimes be seen extended nearly straight backward in an apparently passive manner. The zoospores come to rest within a few hours

(Fig. 3, F), unlike those of *Pythiogeton utriforme*, which von Minden found to remain motile for more than 24 hours. Their average diameter after rounding up, of approximately 15μ entitles them to be reckoned among the largest zoospores produced in the Pythiaceae. Germination occurs usually through the production of a single germ tube (Fig 3, H, *b-e*), two or three tubes being less frequent (Fig. 3, H, *a*), and four relatively rare Repetitional diplanetism undoubtedly occurs with some frequency, as is evidenced by the presence in irrigated preparations of empty cyst envelopes, each supplied with an open evacuation tube (Fig. 3, G). The small diameter of the latter structure indicates that evacuation must be, like discharge of the ordinary sporangia of the fungus, and like evacuation of zoospores of species of *Pythium* undergoing similar repetitional development, by continued streaming, rather than by immediate bodily escape of an integrated motile spore as in species of *Phytophthora*. It is often to be observed that zoospores are more inclined to come to rest, and therefore accumulate in much larger numbers beneath heavy mycelial mats than in open water. This behavior, expressive perhaps of some obscure adaptation to conditions prevailing in the natural habitat, stands in contrast with such different behavior as is revealed, for example, in the zoospores of *Pythium salpingophorum* Drechsl which after coming to rest often float individually but in countless numbers on the surface of the water, or in the zoospores of *Pythium butleri* Subr , which in especially prolific preparations, are to be found floating on the surface of the water in agglutinated masses visible collectively to the naked eye as supernatent scum, each mass consisting of hundreds and sometimes of thousands of individuals. Frequently, as in other Pythiaceous fungi, sporangial discharge is frustrated in greater or smaller measure, the protoplasmic material retained within the envelope nevertheless then ordinarily undergoing the same development as the material discharged Because the evacuation tube is usually, if not always, too narrow to permit the imprisoned motile zoospores to escape, these finally encyst within the sporangium, sometimes in numbers up to a dozen or a score (Fig. 5, B-D).

The sequence of events described above is, as has been mentioned, that regularly observed to be associated with zoospore formation when the mass of protoplasm happens to be largely or wholly submerged in water, as is usually the case when washed mycelium is employed. When, however, the protoplasmic mass is more nearly superficial, as, for example, in preparations of carefully moistened pieces of agar culture, an event often intervenes which may be of more than minor significance in relation to the essential nature of the reproductive mechanism here

concerned. Very soon after the sporangial contents have completed their passage through the evacuation tube, the entire discharged mass suddenly disappears from view, the disappearance being marked by a violent recoil of the tube. Manifestly the body of protoplasm is shot away and that with considerable force. A search over an area several millimeters in diameter failed in every instance to discover the projected mass, and it would seem possible therefore that projection ranges somewhat of the same order as those prevalent among certain of the Entomophthoraceae might be represented here. Owing to the suddenness with which the throwing is accomplished, it has been impossible to observe directly either in what the mechanism here operative may consist, or in what manner it is set off, or again in what wise it engages the discharged sporangial contents. Appearances, however, indicate the vesicle membrane as the effective mechanism. The mushrooming and buckling of the protoplasmic column as it thrusts against the distal part of the vesicle gives the impression that the latter is exerting some backward pressure against its continued inflation. The stretched membrane of the elongated vesicle might then conceivably constitute an element comparable as a mechanical contrivance with the drawn rubber band of a toy catapult

Several circumstances favor the view that the shooting away of the protoplasmic mass represents not only a normal event in the asexual reproduction of the fungus under consideration, but the very event in relation to which the peculiarities attending zoospore formation in the genus find plausible explanation. Thus the elongated shape of the vesicle, so markedly different from the spherical shape prevalent in other genera of Oomycetes, appears as an intelligible functional adaptation when the vesicle membrane is considered as a casting device, for obviously a pouch-like element stretched mainly in one direction would be more efficient in such capacity than one stretched outward uniformly in all directions. The conversion of the vesicle membrane to a mechanical function would almost necessarily preclude continuation of a protective function, for even if the membrane were not seriously torn on snapping the mass into the air, it could hardly escape being badly ruptured on striking at the end of its flight. The noteworthy feature that zoospores are regularly formed from the protoplasmic mass in an entirely naked condition could therefore be interpreted as a further adaptation consequent to the abandonment by the vesicle membrane of a protective in favor of a mechanical function.

Like *Pythium diacarpum*, *Pythiogeton utriforme*, *Pythiogeton transversum* and *Pythiogeton ramosum*, the fungus under discussion frequently

shows proliferation of a secondary sporangium within the empty envelope of a primary one (Fig 3, D, Fig 5, E, F). The evacuation tube of the secondary sporangium usually finds its way through that of the primary one, though instances in which the wall of the primary sporangium or its evacuation tube is perforated to permit egress are not of rare occurrence. Such perforation is, of course, somewhat more frequent when the evacuation tube of the primary sporangium is of considerable length.

In this connection it may be pointed out that von Minden's assertion to the effect that evacuation tubes comparable in length with the tubes produced by his three species of *Pythiogeton*, did not occur in the genus *Pythium*, would seem to stand in need of revision In some species of *Pythium* with mostly filamentous sporangia, as, for example, *Pythium complens*, evacuation tubes measuring 0 5 mm or more, are readily encountered To be sure when *Pythium complens* is cultivated under aquatic conditions, so that the sporangium, except for scattered discrete lobulations, consist of outwardly undifferentiated filaments, the evacuation tube below the expanded terminal part is not easily distinguished as a special element. When, however, the same fungus is first cultivated on relatively dry substrata like the agar media usually employed, so that in the course of time massive lobulate complexes are formed, and subsequently aquatic conditions are provided through suitable irrigation, the evacuation tubes then produced, which naturally are clearly differentiated from the massive complexes from which they arise, often include among shorter ones, many measuring between 100 and 500 μ in length Evacuation tubes of comparable lengths are to be seen in abundance in irrigated preparations of *Pythium periplocum* Drechsl , having their origins here also in massive lobulate complexes

Although a relatively bulky sporangial body may be regarded as one of the requirements for the production of a markedly long evacuation tube, it is not to be assumed that the length of the latter structure is determined solely by the mass of underlying living material The evacuation tubes shown in von Minden's figures of his species of *Pythiogeton* are certainly not remarkable for length In preparations of *Pythium complens* and *Pythium periplocum* short as well as long tubes are to be found The essential utility of the evacuation tube in the Pythiaceae generally, through which, in large part, length and in some species position of origin are governed, is perhaps best revealed when forms are considered in which the structure in question is regularly absent

Among such Pythiaceous forms are to be numbered all the known

members of the genus *Phytophthora*. In these plants the sporangia never give rise to any well-defined cylindrical outgrowth by way of which the zoospores, fully fashioned, are allowed to escape, the distal protrusion occurring occasionally in the parasite described by me (13) under the name *Phytophthora megasperma* representing perhaps as close an approach to such an outgrowth as the genus provides. The refractive, often somewhat expanded cap surmounting the evacuation tube in species of *Pythium*, and through the yielding of which the contents are enabled to pass out of the sporangium, here finds its homologue in the gelatinized apical portion of the sporangial wall itself Where, as in some species, this gelatinized part is relatively thick and of small extent, it protrudes from the sporangium as a definite papilla, where, on the other hand, it is of greater extent and not markedly thickened, the outward contour is not locally modified. In any case the zoospores are regularly fashioned within the sporangium to be liberated from the aperture left by the yielding of sessile papilla or homologous non-protruding apical part In the laboratory, as has been pointed out earlier (11), zoosporangia of such amphibious species as *Phytophthora citrophthora* (Sm. and Sm) Leon and *Phytophthora erythroseptica* Pethyb. are, on the whole, produced in much greater number and zoospore production is subject to fewer mishaps when mycelium, instead of being flooded under excessive water, is kept rather sparingly irrigated The uncounted number of sporangia then often brought forth very promptly, are readily seen to be localized, for the most part, in the layer in which air and water are both intimately available. This positional relationship is made possible evidently by the elongation of the very slender sporangiferous extramatrical hyphae to such lengths as the circumstances may require In other words, associated with the absence of an evacuation tube, and the consequent necessity of having the sporangium at the very outset placed in a position where the requirements for water and air are alike provided, the slender hyphae keep on growing out until the necessary combination of conditions are encountered, their small diameter, usually measuring about 2 μ, permitting of such lengthening with obvious economy of material The more nearly spherical, thick-walled resting sporangia or chlamydospores produced in addition to the ellipsoidal sporangia in such species as *Phytophthora parasitica* Dastur, though evidently morphologically homologous, betray their distinctive character not only by positive adaptation for delayed germination expressed in shape and in thickness of wall, but also by habitual maladjustment for immediate germination implied in deeply submerged position, in intramatrical origin and in frequently intercalary hyphal relationship

Pythium anandrum Drechsl. presents in its sporangium and sporangiferous hyphae remarkable similarity to the genus *Phytophthora* The sporangium of this fungus is similarly ellipsoidal, and dehiscence whenever observed has been found to be effected by means of a well defined, entirely sessile, apical papilla, though in some cases an apical outgrowth was found suggesting an evacuation tube in appearance. As zoospore formation takes place in a sessile vesicle, and therefore in immediate proximity to the sporangium, the circumstances under which it proceeds is determined here hardly less definitely by the position of the sporangium than in species of *Phytophthora*, and as might be expected, the sporangium is similarly borne terminally on a slender, mostly unbranched, extramatrical hypha often several millimeters in length.

A condition more or less transitional with respect to the importance of the sporangiferous hyphae between that found in *Pythium anandrum* on the one hand, and that prevailing among the generality of congeneric species with subspherical sporangia on the other, would seem to be represented in the members of the *helicoides* series described by me earlier, *Pythium helicoides*, *Pythium oedochilum*, *Pythium polytylum* and *Pythium palingenes* In these species the sporangium, ovoid, obovoid, ellipsoidal or subspherical in shape, is again, for the most part, borne terminally on a delicate extramatrical hypha, simple or only sparingly branching, and of variable, often very considerable length Dehiscence is effected here often through the yielding of a hyaline cap surmounting an apical evacuation tube so short that a sessile papilla is closely approximated, but in other instances an evacuation tube of greater length is produced mostly from the apex of the sporangium, but also, especially after frustration of an apical tube, from any other part Presumably the sporangiferous hypha functions here in the same way as in *Phytophthora* or in *Pythium anandrum,* though apparently not always with equal finality Entirely similar relationships naturally are associated with sporangial development in the *Pythium proliferum* of Dissmann (9) and the *Pythiomorpha gonapodioides* of Kanouse (16), both evidently to be included in the *helicoides* series, and would seem to obtain also in some congeneric species of less certain immediate affinities, as, for example, the *Pythium proliferum* of DeBary, of Butler and of Matthews (19), and the *Pythium undulatum* of Petersen (22) and of Dissmann.

In the generality of species of *Pythium* with subspherical sporangia, the latter structures are borne in a more promiscuous manner, occuring rather indiscriminately as intercalary, laterally intercalary, lateral or

terminal bodies on hyphae not differentiated from the vegetative filaments either in diameter or in frequency of branching. Under conditions suitable for immediate production of zoospores, no precise positional relationship to water and air prevails In the absence of such conditions, just as in the case of *Pythium complens* already referred to, sporangia may nevertheless be formed in quantity. In either case, zoospore production entails the development of an evacuation tube, indeterminate with regard to place of origin, to direction, and within the limits imposed by the size of the sporangium, to length. Obviously, the function of seeking out a suitable locus for zoospore formation presumes a certain degree of adaptability, whether the element performing this function is a sporangiferous hypha or an evacuation tube.

With respect to their relationships to supporting hyphae and evacuation tubes the temporary sporangia produced by the American species of *Pythiogeton* under consideration invite comparison with the sporangia of such species as *Pythium helicoides* in some particulars, and with those of such forms as *Pythium complens* in others The sporangiferous filaments are for the most part narrow, though because of the small diameter of many of the intramatrical hyphae, their degree of differentiation is not pronounced In length these filaments show considerable variation, yet, nevertheless, so do also the evacuation tubes (Fig. 4, G-L, Fig 5). In some instances the evacuation tube grows to a length of several hundred microns, manifestly without encountering conditions permitting it to function Under such circumstances, a septum may be inserted some distance from the sporangium, while the proximal part puts forth a lateral branch through which evacuation subsequently takes place. Indeed, as is shown in Figure 3, C, a second branching of the evacuation tube may occur before the final element has occasion to fulfil its function, or the later branch or branches may be produced without any septum making its appearance anywhere in the parent evacuation hypha (Fig. 5, B, C).

In the proliferation of a secondary sporangium within or from within a primary one, the fungus isolated from leaves of cat-tail, like the three species described by von Minden and like *Pythium diacarpum*, shares a feature exhibited also in the various groups of the Pythiaceae, in which, as has been set forth, the sporangia are frequently, if not regularly, terminal on slender filaments, and discharge always or at least in large part, by means of an apical papilla or an apical evacuation tube. As proliferation enables a number of sporangia to be produced in place of one, often at a considerable distance from the vegetative mycelium in which the frequently long sporangiferous hypha has its origin, an

economy of material in addition to that accruing from the slenderness of the hypha is made possible. DeBary in his discussion (3) of *Pythium proliferum*, early pointed out that proliferation of a secondary sporangium within or from within an evacuated primary one, was essentially similar to the production of a second sporangium either immediately beneath the basal septum setting off the first, or at some distance on a prolongation of the supporting hypha. Butler later discussed more fully the similarity between subsporangial branching and proliferation, stating that subsporangial branching "is especially to be expected where growth is vigorous, but conditions are not such as to favor zoospore formation." Now one of the chief differences between a terrestrial and an aquatic habitat is that in the former, conditions suitable for mycelial growth and for production of sporangia are naturally much less frequently concomitant with conditions suitable for zoospore formation, in which process sporangial dehiscence is necessarily entailed, than in the latter. Therefore, if allowance is made for the developmental adaptation appropriate for this lack of concomitance, and for an additional adaptation in ready detachability of sporangia— an adaptation for dispersal by such atmospheric agencies as wind or moving rain water—it becomes apparent that a nested or serial arrangement of sporangial envelopes on a single axial filament constitutes the aquatic counterpart of the spicate arrangement revealed by the more nearly terrestrial or even folicolous forms, as, for example, *Phytophthora infestans* (Mont.) DeBary and the species usually designated as *Phytophthora cactorum* (Cohn and Leb.) Schroet.

When the fungus from decaying cat-tail tissue is cultivated on agar substrata some temporary sporangia of typical bursiform shape may be produced, these making their appearance most often on the surface of the culture, and there preferably in places where small quantities of free liquid water, as, for example, droplets of water of condensation, are available. Ordinarily, however, the reproductive bodies produced within and on the surface of substantially dry substrata or moderately hard agar media, or, for that matter, in liquid media containing plenty of food material in which a mycelium has been left growing undisturbed for a week or more, are of approximately spherical shape (Fig. 1, C; Fig. 4, A-D). They exhibit the various kinds of attachment shown by the temporary sporangia, though, as might be expected, they are more often borne on relatively short hyphal branches. With regard to size they show, especially when formed in large numbers, an approach to uniformity that may be held to indicate some degree of representativeness of the morphology of the species. Measurements

of the diameter of 100 of the spherical bodies, produced on string-bean agar (decoction of 500 grams green pods of *Phaseolus vulgaris* L., 20 grams agar-agar, with water sufficient to make up to 1 liter) and selected at random 15 days after planting yielded values expressed to the nearest micron as follows 32μ, 1, 33μ, 3, 34μ, 4, 35μ, 1, 36μ, 6; 37μ, 9, 38μ, 10, 39μ, 10, 40μ, 11, 41μ, 10, 42μ, 8, 43μ, 5, 44μ, 8; 45μ, 2, 46μ, 6, 48μ, 2, 49μ, 2, 50μ, 1, 51μ, 1 From these values an average of 40.4μ was computed

Although the typically bursiform sporangia, as also the typically subspherical structures, can sometimes be found with very little admixture of one another, the two kinds of reproductive bodies more often appear side by side in variable proportions Ordinarily, too, intergradations of all sorts can be observed. Therefore little doubt can be entertained that the two types of bodies are homologous structures They are, for the most part, also similar in function, for when the subspherical bodies are put in water within several weeks or often even within two or three months after being formed, zoospores are produced following developmental processes entirely similar to those described for the bursiform bodies. The two types differ, however, with respect to longevity, since the bursiform sporangia can not very readily be kept alive for a period of more than two or three weeks, whereas the globose bodies frequently show after three months a vitality little impaired except for an increasing tendency from zoospore formation toward vegetative germination A parallelism to the bodies concerned in the asexual reproduction of the fungus I described in an earlier paper (10) as *Plectospira gemmifera* is easily recognizable. For manifestly the bursiform sporangia, like the complexes of inflated elements in the Saprolegniaceous fungus, are essentially short-lived structures generally formed under conditions suitable for immediate production of zoospores, whereas the subspherical bodies are long-lived structures generally formed under conditions little suitable for immediate production of zoospores

As the subspherical sporangium becomes older, a central vacuole or reserve globule becomes larger and larger, until after several months the granular protoplasm is reduced to a relatively thin parietal layer (Fig. 4, E, F). It appears probable that some increase in thickness of the enveloping wall also takes place, as after evacuation, the empty membrane of an older sporangium (Fig. 4, G, H) shows somewhat less relaxation than that of a younger one. Whether the responsibility of conserving the fungus during unfavorable periods devolves entirely upon the globose sporangia is not known, though certainly oospores

have not hitherto been found in any cultures either mixed or pure, in spite of the varied substrata and the varied cultural conditions that have been brought into play.

The persistent failure of the fungus under consideration to form sexual organs may perhaps indicate a difference of taxonomic import separating it from *Pythiogeton utriforme* and *Pythiogeton transversum*. However, among aquatic fungi including those of indubitably homothallic nature, strains to be recognized as unquestionably conspecific, nevertheless often show marked differences in regard to the readiness with which the sexual reproductive stage can be induced. Nor is it to be forgotten that von Minden harbored misgivings concerning the actual association of the two sorts of sexual apparatus observed by him in gross cultures with the sporangium-bearing species to which he somewhat provisionally assigned them. Indeed, some misgivings might even be entertained concerning the sexual character of the structures which von Minden presented as oogonium, antheridium and oospore of *Pythiogeton utriforme*. For the fusion of oospore wall with oogonial wall necessarily brings into the question the morphological separateness of the two, the antheridium as figured shows neither the shape nor the relative size usual for male organs, and the ripe oospore besides being surrounded by a wall which in respect to thickness is most extraordinary, would not seem to reveal in its contents any type of organization recognized as distinctive of oospores. However these disturbing considerations are far from being decisive. The unusually thick oospore wall, the massiveness of which would be elsewhere, and perhaps even here is interpretable as the result of gelatinous swelling accompanying degeneration of the contained protoplast, is at any rate found also in the unambiguously sexual apparatus attributed to the congeneric *Pythiogeton transversum*. In *Pythium complens* and even more in *Pythium salpingophorum* and *Pythium papillatum* Matth. (18), the oogonial envelope is extensively fused with the oospore wall, yet in spite of such fusion, and in spite moreover, of the absence of any antheridia in *Pythium papillatum* and the usual absence of male organs in *Pythium salpingophorum*, the presence of authentic oospores or of homologous parthenospores in these species is sufficiently attested in an internal organization revealing unmistakably a central reserve globule, a parietal protoplasmic layer and an imbedded refringent body, in addition to an external wall of moderate, not excessive, thickness.

It may be noted in this connection that the fusion of oogonial and oospore walls apparent in the three fungi last mentioned, while not as thoroughgoing as in the sexual apparatus ascribed to *Pythiogeton utri-*

forme, nevertheless abates very considerably the foreignness to the genus *Pythium* which von Minden imputed to this feature. Similarly the involvement of the filament bearing one of the sexual organs by the filament bearing the other is certainly no longer unknown among species of *Pythium*. Indeed such involvement might very probably have been discovered in the latter genus much earlier, but for optical difficulties, which today, with transparent artificial substrata and greatly improved equipment, can at least in some instances be more successfully overcome. Thus in favorable preparations of the fungus described by Braun (5) under the binomial *Pythium complectens*, but which almost certainly must have been the same as that from which DeBary earlier drew at least one of the figures (3 pl. 5, fig 4) illustrating the sexual apparatus of his *Pythium vexans*, the antheridial branch can be seen to pass around the oogonial stalk usually to the extent of a half turn, or of a whole turn In *Pythium perilum* Drechsl. branching prolongations of the antheridial hypha are often wrapped for several turns about the oogonial hypha. Recently Vanterpool and Truscott (26) described a fungus under the binomial *Pythium volutum*, the antheridial hyphae of which are stated to coil commonly around the oogonial stalk, or less frequently around an adjacent hypha To be sure in these various species, the involvement found would seem scarcely comparable with that described and figured for *Pythiogeton transversum*, being neither constant in occurrence, nor especially regular in a geometrical sense In *Pythium helicoides*, however, involvement of the oogonial hypha by a filamentous element having a close mycelial relationship to one of the male organs is both regular in occurrence and of conspicuous geometrical symmetry, and similar helicoid inwrapment occurs, though with less constancy, in all the immediately related species of which I have seen any sexual apparatus at all It is not improbable, therefore, that when the mycelial relationships of the sexual organs of the fungus discussed by Kanouse under the name *Pythiomorpha gonapodioides* are better known, the same sort of coiling will be recognized among the morphological features of that form In that event Kniep's (17) characterization of the antheridial branches found in *Pythiomorpha* together presumably with those of *Pythiogeton* as "den Oogonstiel oft spiralig umschlingende Schlauche,"—a characterization to be explained most plausibly perhaps as the result of a misunderstanding of Kanouse's statement that "The antheridial branch winds about the oogonium,"—would receive factual confirmation to the extent to which Kanouse's fungus might be held to be representative of *Pythiomorpha*.

For such representativeness neither the original application nor most subsequent usage offers much support. The irregular intramatrical hyphae and the emission of ready-fashioned zoospores from the sporangia, ascribed by Petersen to the fungus on which the genus in question was based, points rather definitely to a species of *Phytophthora* with a proliferating habit. Because of the same considerations, supported besides by additional similarity suggested in the application of the antheridium near the base of the oogonium, von Minden's account of his *Pythiomorpha gonapodioides* likewise indicates, and with even greater probability, a proliferous species of *Phytophthora*. Similarly proliferous species of *Phytophthora* would seem to be represented also in the fungi newly described by Ito and Nagai under the binomials *Pythiomorpha miyabeana* and *Pythiomorpha oryzae*, the ostensibly intercalary "gemmae" of which show unmistakable general resemblance to the promiscuously vegetatively proliferous bodies apparently interpretable as sporangia of frustrated development, that are often formed terminally on extramatrical hyphae in various species of *Phytophthora*, as, for example, in notable abundance in the American pink-rot fungus to which reference was made in an earlier paper (11) as *Phytophthora erythroseptica*, and which later was described by Tucker (25) as an independent species under the binomial *Phytophthora drechsleri*. Owing to the absence of sexual structures, and to the somewhat inconstant and often rather rudimentary development of the evacuation tube, the immediate affinities of *Pythium undulatum* which Apinis (1) transferred to *Pythiomorpha* remain much more conjectural. If it be assumed—what there is much reason to doubt—that the Pythiaceous plants dealt with by the several authors under the specific term *undulatum* were, indeed, all conspecific, articulation with such more exceptional proliferous types as *Pythium anandrum*, or *Pythium proliferum* or even *Pythium megalacanthum* may be as well within the realm of possibility as membership in the *helicoides* series or in *Phytophthora*. In any case it is apparent that representatives of at least two groups of Pythiaceous fungi, separated by very obvious differences in their more distinctive antheridial relationships and in oospore structure, have been assigned to *Pythiomorpha*; and of the two only the one less frequently, and apparently also less correctly, thus assigned would conform to the characterization by Kniep relative to the coiling of antheridial filaments in the manner illustrated presumptively in *Pythiogeton transversum*. It is to be noted, moreover, that in all species of *Pythium* in which involvement has been observed, the antheridial branch winds about the oogonial hypha, whereas in *Pythiogeton*

transversum, according to von Minden's account, the reverse condition is the one more abundantly represented, the prevailing relationship being therefore more comparable to that occurring in various species of *Aphanomyces*, as, for example, in *A. camptostylus* Drechsl., in *A. cladogamus* Drechsl., and in the form from pansy roots which Meurs (21) designated, though evidently somewhat unhappily, as *A. euteiches* P.F. 2.

Although appearance of the antheridium at a very early stage in the development of the oogonium, held by von Minden to be a distinctive feature of the genus *Pythiogeton*, is not frequent among species of *Pythium*, approximately equally early development of the male organs is to be observed in the two species described by me (12) under the names *Pythium polymastum* and *Pythium mastophorum*. Early appearance of the antheridium is to be noticed also in cultures of the closely related fungus that Buisman (6) and later Diddens (8) found occurring on flax roots in Holland and discussed under the binomial *Pythium megalacanthum*.

Evidently then some of the features which von Minden considered as distinguishing *Pythiogeton* from *Pythium* are in reality not altogether foreign to the latter genus. Yet after making allowance for the similarities to one or another of the various series of forms included in *Pythium*, the fungi assigned to *Pythiogeton* present in common such a degree of distinctiveness that continued maintenance of the separate genus for them seems altogether appropriate. However, disposition of the fungus isolated from decaying cat-tail material to a place within this genus is in some degree, a matter of conjecture The uncertainty surrounding such disposition is due mainly to the fact that von Minden directed his attention more to features pertaining to the genus than to the peculiarities marking each of the several species. Indeed, it is probable that in the water cultures employed by him the sort of peculiarities that contribute largely to the individuality of a species may not have been well expressed. The problematical taxonomic import attaching to the greater width of the vegetative hyphae found in cultures of the present fungus, and to the absence of a sexual stage, has already been discussed. Significant differences from the description of *Pythiogeton utriforme* can perhaps be read into the frequent production of an intercalary sporangium a very short distance from the tip of the supporting hypha, as well as into the much shorter period of motility of the zoospores, though ordinarily such details would not impress one as especially decisive. The smaller dimensions of the sporangium and the inferior length of the distal hyphal appendage, when an appendage is

present, would seem to indicate somewhat more definitely that the fungus under consideration is not to be identified as *Pythiogeton transversum*. Even when sporangia are borne in dense arrangement or in heaped masses (Fig. 1, B, *a*), no conspicuous branching of stout sporangiferous hyphae, such as was set forth in von Minden's description of *Pythiogeton ramosum*, is to be observed. The sporangia of Sparrow's *Pythiogeton ramosum*, generally measuring, according to the description of that author, 60μ in length and 20μ in greatest transverse diameter, are evidently considerably smaller than those of the fungus in question, and similar inferiority in size is to be inferred with respect to the subspherical sporangia of *Pythium diacarpum* which Butler described as having a diameter of about 30μ. That the fungus in question is different from any of the forms originally described as species of *Pythiogeton* or presumed to be referable to that genus certainly can not be at all strongly asserted. Yet, on the other hand, to assert an identity with any one of these forms would be even more difficult, as such assertion would entail outright contradiction of some part of the very limited body of diagnostic detail contained in the descriptions. The fungus is therefore described here, somewhat reluctantly, as a new species.

Pythiogeton autossytum sp. nov.

Intramatrical mycelium composed of hyphae branching mostly at rather wide angles and at moderate intervals, measuring 1.6 to 7.0μ in diameter, each element maintaining usually a nearly uniform width from origin to tip, the wider axial hyphae of straightforward course, the shorter branches usually with somewhat abrupt changes in direction, and often bearing appressoria in groups of 5 to 10 or more, the individual appressorium distended clavate, mostly 10 to 13μ in diameter and 20 to 30μ in length, after functional frustration often growing out into irregular processes of somewhat crescentic parts. Under aquatic condition extramatrical mycelium rather meager. Aerial mycelium on dry substrata generally meager, arachnoid, yet often spreading rather extensively over surfaces of adjacent bodies.

Sporangium terminal or intercalary, when intercalary mostly borne only a short distance from the tip of the supporting filament, the distal element mostly 3 to 30μ in length remaining as an empty appendage, when produced under conditions suitable for zoospore production sometimes subspherical or ellipsoidal, but more often markedly ventricose, utriform, or bursiform, with the expanded part free and its axis directed athwart the axis of supporting hypha, or occasionally bilocular as through fusion of two parts, either of which may be subspherical or bursiform, measuring 16 to 226μ, mostly 50 to 150μ (average 96μ) in length and 13 to 68μ, mostly 30 to 54μ (average 42μ) in greatest diameter, when formed under conditions unsuitable for zoospore formation, mostly subspherical measuring usually 32 to 51μ (average 40.4μ) in diameter. Evacuation tube arising often from position opposite attachment of supporting filament and directed in approximate alignment with that filament, but at other times originating from other positions, measuring

mostly 3 5 to 7 0μ (average between 5.5 and 6.0μ) in diameter, and 5 to 300μ in length, in cases of frustration often becoming septate, and discharging from a branch Zoospores formed up to approximately 100 from a single sporangium, broadly reniform, the longitudinal furrow bearing the two cilia well-marked, the forward end more pointed than the rounded rear end, measuring mostly 18 to 20μ in length and 11 to 13μ in width in motile state, after rounding up measuring mostly 13 to 17μ (average 15μ) in diameter, germinating individually by the production of 1 to 4 delicate germ tubes, or giving rise to a secondary zoospore after proliferating an evacuation tube approximately 2μ in diameter, and 2 to 27μ in length

Isolated from dying and decaying leaves of *Typha latifolia* L collected near Port Clinton, Ohio, October, 1931

Mycelium ramosum, hyphis 1 6—7 0μ crassis Zoosporangia terminalia et intercalaria globosa vel ellipsoidea plerumque 31—51μ (media circ 40μ) diam, aut saepe elongato-ovoidea et in hyphis transverse et inaequaliter disposita, interdum biloba, 16—226μ saepius 50—150μ (media circ 96μ) longa, 13—68μ saepius 30—54μ (media circ. 42μ) lata Zoosporae majusculae, maturitate plerumque 13—17μ diam Oogonia et oosporae ignotae

Hab in foliis morientibus Typhae latifoliae, Port Clinton, Ohio

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ENTOMOLOGY.—Strategus simson *L. and related West Indian species (Coleoptera. Scarabaeidae)*.[1] EDWARD A CHAPIN, Bureau of Entomology. (Communicated by HAROLD MORRISON)

In connection with a taxonomic study of the Cuban Dynastinae, all available material of the supposed species *Strategus titanus* (Fab.) was examined. This "species" is found on various islands of the West Indies, the 163 specimens at hand coming from Jamaica, Cuba, Santo Domingo, Navassa, Porto Rico, and St Croix Each of the four major islands of this list supports a form which differs consistently from the others in certain external characteristics and in the conformation of the aedeagus. A single specimen from Navassa, the only one seen, appears to be identical with specimens of similar development from Santo Domingo, and a few specimens from St Croix are like corresponding individuals from Porto Rico. One specimen, a female, from near Jean Rabal, Haiti, certainly belongs to the Cuban species and not to the native; its presence in Haiti is evidence of the shifting of species by commerce or by some natural agency.

Up to the present, five names have been proposed in this group. These are given below in chronological order of their publication and an effort has been made to apply them to one or another of the species recognized here as distinct.

[1] Received June 8, 1932

Scarabaeus simson L., 1758.—This species was based solely on the works relating to the Jamaican fauna of Sloane[2] and of Browne, in which works the insect is passably figured. There can be no argument against the acceptance of this name for the Jamaican species.

Scarabaeus eurytus Fab., 1775.—This name is said to be based on a female specimen from the Hunter Collection and is accompanied by a description too inadequate to insure recognition. The type specimen, now at Glasgow, has been reexamined, and is a small male. The species is considered by R. A. Staig, 1931, as a synonym of *S. titanus* Fab.

Scarabaeus titanus Fab., 1775.—For some reason not evident to the present writer, Fabricius transferred the Linnean name, *S. simson*, to an Indian (East or West ?) species said to be related to *S. acteon* L. and established the new name *titanus* for the Jamaican species, citing the volumes of Drury and Sloane. As Drury had already adopted the Linnean name in his work, and as the Sloane citation by Fabricius is identical with the Sloane citation by Linnaeus 1758, and as Drury's figure evidently refers to the Jamaican species, this Fabrician name must drop into synonymy under *S. simson* L.

Scarabaeus aenobarbus Fab., 1775.—Again it appears impossible to identify this species from the description. The type is in the Hunter collection and in 1792 Fabricius himself merged this species with *S. eurytus* Fab. Olivier has included Jamaican specimens under this name and it appears that he considered Fabricius's specimen a small male of *S. simson* L. An examination of the type has been made by R. A. Staig, 1931, and he places this name in the synonymy of *S. titanus* Fab.

Scarabaeus ajax Oliv., 1789.—The locality whence came the type of this species was not known to Olivier but an examination of his published figure leaves no doubt in the writer's mind that Olivier was dealing with the Cuban form. The development of the anterior thoracic horn as portrayed is typical of this species only.

Thus there are two names, *simson* and *ajax*, available for two of the four species now before the writer, and these four may be distinguished in the following manner.

KEY TO MALES

1. Posterior margin of sixth abdominal sternite set with multiple rows of long, gently curved, contiguous hairs, lateral lobes of aedeagus each without angular prominence on outer margin near apex (Figures 5, 6), Porto Rico, St. Croix .... **barbigerus** n. sp.
   Posterior margin of sixth sternite set with a single, or at most a double, row of long, straight hairs, which are spaced by at least their own diameters, lateral lobes of aedeagus each with a more or less well developed angular prominence on outer margin near apex 2
2. Discal portion of elytra without ocellate punctures; in specimens of major development the anterior median horn widened and rather deeply forked at apex, and the posterior lateral horns long and slender (aedeagus as in Figure 1), Jamaica .... **simson** L.

[2] For complete citations, see under respective species below.

Discal portion of elytra with more or less regular rows of ocellate punctures, anterior median horn never strongly widened or deeply forked at apex, posterior lateral horns never long and slender 3

3. Lateral margin of each lobe of aedeagus extended near apex in a spiniform process (Figures 2, 3), males of major development not seen, possibly absent, anterior median horn of pronotum slender, Santo Domingo, Navassa **laterispinus** n sp.

Lateral margin of each lobe of aedeagus not extended in a spiniform process (Figure 4), males of major development frequent, anterior median horn of pronotum usually stout and parallel-sided, Cuba (introduced on Santo Domingo) **ajax** Oliv

KEY TO FEMALES

1 Discal portion of elytra without ocellate punctures (pygidium as in Figure 7) . **simson** L

Discal portion of elytra with at least two, sometimes with several, incomplete rows of ocellate punctures 2

2 Pygidium not strongly protuberant at middle (Figure 10) and not overhanging the apical margin of the sclerite, its apical portion sparsely punctured **barbigerus** n sp.

Pygidium strongly protuberant at middle (Figures 8, 9), overhanging the apical margin of the sclerite, its entire surface densely punctured or sculptured . **laterispinus** n sp and **ajax** Oliv

DESCRIPTION OF SPECIES

The four species described below have the following characteristics in common

Size large to very large, from 24 to 42 mm (exclusive of horn), form robust, sides subparallel, apical half of elytra broadly rounded, color castaneous to piceous-black, vestiture of pygidium and underparts ferrugineous Head subtriangular, apex of clypeus truncate and reflexed in male, minutely bidentate in female, clypeofrontal suture bearing two small, widely separated tubercles Pronotum polished, finely margined and finely to coarsely sculptured just inside marginal bead, with an anterior median excavation which, in the male, is bounded posterolaterally by two more or less well-developed horns or bosses, anterior margin of male prolonged at middle in a horn, the apex of which is usually notched Elytra dull, alutaceous Propygidium with a median series of coarse stridulatory ridges Pygidium of male strongly convex, of female from nearly vertical to strongly convex Posterior margin of sixth sternite of male broadly truncate to emarginate. Anterior tibia quadri- (rarely tri-) dentate, anterior tarsus about as long as anterior tibia Middle and posterior tibiae each with two well-developed oblique setigerous ridges, apex of middle tibia with two nearly equal acutely triangular digitations, posterior tibia with three unequal digitations, the middle always the smallest

In the descriptions which follow, it is to be understood that there is no definite line of demarcation between major and minor forms in the male sex. In each case, the extremes of variation have been described.

STRATEGUS SIMSON (Linnaeus)

Scarabaeus major niger tricornis Sloane, 1725, Voyage Jamaica, Vol. 2, p. 205, Pl 237, Figs 4, 5.

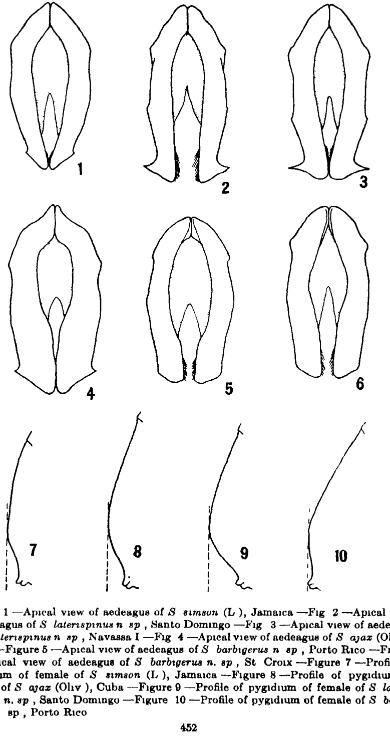

Fig 1 —Apical view of aedeagus of *S simson* (L), Jamaica —Fig 2 —Apical view of aedeagus of *S laterispinus n sp* , Santo Domingo —Fig 3 —Apical view of aedeagus of *S laterispinus n sp* , Navassa I —Fig 4 —Apical view of aedeagus of *S ajax* (Oliv), Cuba —Figure 5 —Apical view of aedeagus of *S barbigerus n sp* , Porto Rico —Figure 6 —Apical view of aedeagus of *S barbigerus n. sp* , St Croix —Figure 7 —Profile of pygidium of female of *S simson* (L), Jamaica —Figure 8 —Profile of pygidium of female of *S ajax* (Oliv), Cuba —Figure 9 —Profile of pygidium of female of *S laterispinus, n. sp* , Santo Domingo —Figure 10 —Profile of pygidium of female of *S barbigerus* n sp , Porto Rico

Scarabaeus 4 Browne, 1756, History Jamaica, p. 428, Pl 43, Fig. 6 (work not seen, citation taken from Linnaeus 1758)
Scarabaeus simson Linnaeus, 1758, Syst Nat, Ed 10, p 345 (above works cited)
Scarabaeus simson Drury, 1770, Illust Ins, Vol 1, Pl 36, Figs 3, 4
Scarabaeus titanus Fabricius, 1775, Syst Ent, Vol 1, p 10 (cites Sloane, and Drury).
Scarabaeus aenobarbus Fabricius, 1775, Syst Ent, Vol 1, p 10
Scarabaeus eurytus Fabricius, 1787, Mant Ins, Vol 1, p 5
Scarabaeus aenoburbns Fabricius, 1787, Mant Ins, Vol 1, p 6 (misprint)
Scarabaeus 4 (*Scarabaeus simson* on plate), Browne, 1789, History Jamaica, p 428, Pl 43, Fig 6 (apparently identical with Browne, 1756, except for addition of Linnaean name on plate)
Scarabaeus titanus Olivier, 1789, Ent, Vol 1, Pt. 3, p 26, Pl 5, Fig 38
Strategus titanus Burmeister, 1847, Handb Ent, Vol 5, p 136 (pars)
Scarabaeus titanus Staig, 1931, Fabrician Types Ins Hunter Colln, Coleopt, Pt 1, pp 80–83, Pl 24

Pronotum Male, major development Anterior horn about twice as long as diameter of head across eyes, rectangular in cross section near base, upper lateral margins finely but distinctly beaded, dorsal surface with but a faint trace of median carina, sides divergent anteriorly so that extreme apex is about twice as wide as narrowest part, apex deeply, triangularly notched, the points on either side of the emargination acute Posterior lateral horns elongate, compressed, each nearly as long as anterior horn, with sides convergent to the rounded apex Pronotal surface shining, impunctate Male, minor development Anterior horn conical, about one-third as long as diameter of head across eyes, extreme apex with a small triangular notch Posterior lateral horns reduced to low bosses, each finely and rather densely punctured Female Anterior horn reduced to a minute tubercle placed about twice its diameter behind the anterior margin of the pronotum, posterior lateral horns absent, behind the tubercle a circular depression whose diameter is from one-fourth to one-third the greatest diameter of the pronotum, surface of the depression, anterior third of pronotum, and flanks coarsely sculptured, rest of surface finely and rather sparsely punctured

Elytra Lateral margin finely beaded, sutural margin broader and set off from disc of elytron by a deep, crenulated groove Surface minutely and moderately closely punctured, with a few coarser punctures scattered over the surface No trace of longitudinal rows of punctures on disc but with two or three partial rows of ocellate punctures on basal half below humerus

Pygidium Male Strongly convex, basal third moderately densely clad with long hairs, apical margin at middle with a thickened lip which is similarly hairy Surface sparsely and rather coarsely punctured Female Vestiture similar to that of male, contour less convex, surface more coarsely punctured At sides, broadly and shallowly depressed along apical margin. Figure 7

Last sternite Male Surface impunctate, apex broadly truncate, margin set with a single, and across truncature with a double, row of stiff hairs Female Surface strongly sculptured basally, finely and very sparsely punctured apically, apex not truncate, margin set with hairs as in male

Aedeagus, Figure 1

Type locality —Jamaica.

Apparently a common species on the island. Thirteen males and twenty-five females from the following localities have been seen Mandeville, Manchester, Balaclava, St Elizabeth, Bazon Hill, Trelauney, Kingston, Bath; Port Antonio, Cuna Cuna, Arntally, Snug Harbor, Montego Bay Among the individuals examined, males of major development are fairly common Possibly of economic interest in connection with the banana industry, as specimens occasionally enter this country on bunches of the fruit

STRATEGUS AJAX (Olivier)

Scarabaeus ajax Olivier, 1789, Ent, Vol 1, Pt 3, p 27, Pl 2, Fig 10
Strategus titanus Burmeister, 1847, Handb Ent, Vol 5, p 136 (pars)

Pronotum Male, major development Anterior horn stout, a little longer than diameter of head across eyes, rectangular in cross section throughout most of its length, upper lateral margins acute, lower lateral margins indistinctly beaded, dorsal surface usually with a well defined though not acute carina, sides nearly parallel, apex with a shallow, triangular notch, the points on either side of the emargination subacute Posterior lateral horns reduced to low compressed pyramidal bosses, acute at apices, with anterior (vertical) margins acute, posterior (horizontal) margins rounded and joined across disc in an even arc, which occasionally is slightly produced on the median line Pronotal surface smooth, finely and sparsely punctured except in the excavation Male, minor development Anterior horn conical, about half as long as the diameter of an eye, extreme apex minutely notched Posterior lateral horns effaced Pronotal surface distinctly and moderately densely punctured Female Similar in development to that of *S simson* (L)

Elytra Lateral and sutural margins much as in *S simson* (L) but with the subsutural groove less deep and more distinctly crenulated Surface with a mixture of very minute and fine punctures, with five or six partial longitudinal rows of ocellate punctures on disc and with as many more below humerus

Pygidium Similar to that of *S simson* (L) except that in the female it is more evenly and strongly convex Figure 8

Last sternite Male Surface with a few fine, scattered punctures and with some slight sculpturing at sides near base, apex broadly, transversely emarginate, margin with vestiture as in *S simson* (L) Female As in *S simson* (L)

Aedeagus, Figure 4

Type locality —Unknown but apparently Cuba

A common species over the island, associated at least occasionally with *Agave fourcroydes* Lem Thirty males and thirty-seven females have been examined, coming from the following localities Cuba Pinar del Rio City, Havana—Santiago de las Vegas, Havana City, Santa Clara -Cayamas, Cienfuegos, Camaguey—Nuevitas, Baragua, Estrella, Jaronu, Oriente—Santiago de Cuba, Baracoa, Guantanamo. Santo Domingo Haiti—Jean Rabal

Strategus laterispinus n sp

Pronotum Male, major development No specimen at all comparable in development to major forms of *S simson* (L) and *S ajax* (Oliv) seen Anterior horn about half as long as diameter of head across eyes, rectangular

in cross section, upper lateral margins and dorsal carina subacute, lower lateral margins not sharply defined, sides parallel, apex with small triangular notch, points on either side of emargination blunt. Posterior lateral horns very low, each arising to a compressed, subacute apex Pronotal surface finely, evenly, and sparsely punctured except in the excavation, which is impunctate but usually with more or less coarse sculpture in its anterolateral regions Male, minor development Anterior horn conical, about as long as the diameter of an eye, evenly rounded from side to side above, subentire at apex Posterior lateral horns almost effaced. Punctation and sculpture as above Female Anterior horn virtually absent, visible as a minute tubercle on only an occasional specimen Anterior half of circular depression more coarsely sculptured than posterior, sides of pronotum likewise more coarsely sculptured than usual, surface otherwise finely and sparsely punctured

Elytra Much as in *S ajax* (Oliv) but with ocellate punctures more densely placed, the rows reaching almost onto the subapical callosities and with the subsutural groove finer and less deep

Pygidium Male Strongly convex, basal fourth densely clad with long hairs, apical margin at middle with thickened lip which is sparsely clad with hair Surface not polished, finely and rather indefinitely punctured, rather coarsely sculptured at sides Female Strongly convex, almost as in the male, coarsely punctured or sculptured over entire surface Lateral depressions deep and moderately broad Vestiture as in male Figure 9

Last sternite As in the corresponding sexes of *S ajax* (Oliv)

Aedeagus, Figures 2, 3

Type locality —Santo Domingo Haiti, Manville

Type and five paratypes in the American Museum of Natural History, seven paratypes in the U S National Museum, Cat , No 44111

Type, a male from Manville, June 10, 1922, paratypes from Haiti Manville, Republica Dominicana– Puerto Plata, Sanchez, San Francisco, Navassa Island

Strategus barbigerus n sp

Strategus titanus Smyth, 1920, Journ Dept Agr Porto Rico, Vol 4, pp 7–21, Pl. 3 (err det)

Pronotum Male, major development Anterior horn about as long as diameter of head across eyes, rectangular in cross section near base, upper lateral margins subacute, dorsal carina absent, dorsal surface conspicuously punctured, sides divergent anteriorly so that extreme apex is half again as wide as narrowest part, apex deeply, triangularly notched, points on either side of notch subacute Posterior lateral horns short, obtuse, compressed, margins not acute, extreme apices right angled Pronotal surface, including excavation, finely and sparsely punctured Male, minor development Anterior horn short, stout, conical, apex minutely notched, posterior lateral horns effaced, pronotal surface, including excavation, coarsely sculptured generally over anterior half, posterior half minutely and sparsely punctured Female Anterior horn reduced virtually to extinction, anterior half of pronotum, including the circular depression, coarsely sculptured, the sculpturing invading the posterior half in the lateral thirds, rest of pronotum finely and sparsely punctured

Elytra Lateral and sutural margins as in the preceding species except that the subsutural groove is crenulate only toward disc, simple toward suture Surface finely and sparsely punctured, with five or six partial rows of ocellate punctures on disc and with three strong rows and many irregularly placed ocellate punctures below humerus.

Pygidium. Male: Strongly convex, basal fifth and apical thickened margin moderately densely set with long hairs Surface smooth and impunctate except along margins, where it is moderately coarsely sculptured. Female: Nearly vertical, sculptured as in *S. laterispinus* n sp. Figure 10.

Last sternite. Male· Surface impunctate, apex broadly truncate or very feebly emarginate, margin set with multiple rows of densely placed, slightly waved hairs, which are mostly directed away from the median line Female. As in *S simson* (L)

Aedeagus, Figures 5, 6

Type locality —Porto Rico Aguirre

Type and twenty-four paratypes in the U S National Museum, Cat, No. 44112, twenty paratypes in American Museum of Natural History

Type: A male from Aguirre, July 20, 1911, J S Orme (P R Sugar Growers Assn, No 116-1911), paratypes· Porto Rico—Aguirre, Aibonito, Caguas, Coamo Springs, Guanica, Isolina, Mayaguez, Ponce, San Juan, Santurce, Santa Isabel, and from Porto Rico without definite locality, St Croix—Christiansted, St John Specimens, probably of this species, have been reported from Vieques Island

Under certain conditions, this species becomes an important enemy of sugar cane For a detailed study of life history and economic status, see Smyth's paper cited above

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY

489TH MEETING

The 489th meeting was held at the Cosmos Club April 13, President MATTHES presiding

Informal communication WILBUR NELSON (University of Virginia) reported the discovery of a coarse conglomerate about 800 feet thick, the lower 120 feet of which contains pebbles and boulders, both angular and rounded, and from 2 to 12 inches in diameter, imbedded in a metamorphosed sediment, now composed of feldspar, blue quartz, and mica The lower 120 feet of these metamorphosed sediments, which lie next to the Lovingston quartz-monzonite, have the appearance of an augen gneiss, or a mylonite

Above the lower 120 feet, there occurs 285 feet of conglomerate full of pebbles from 2 to 6 inches in diameter which become more scattered toward the top Above this middle section of the formation is 345 feet of conglomerate containing pebbles from 1 to 4 inches in diameter This upper part of the conglomerate grades into a mica gneiss, which is correlated with the Lynchburg gneiss The Lynchburg gneiss occupies a belt about one mile wide at this point, and as it has dips of over 70 degrees entirely across its outcrop, its exposed thickness is approximately 5,000 feet The conglomerate and Lynchburg gneiss have a strike of N 30 degrees E, and dips from 70 to 80 degrees to the northwest They are slightly overturned. The boulders and pebbles in the basal 120 feet of the conglomerate are of quartz, granite, and a fine-grained siliceous gneiss. These pebbles and boulders occur in clusters in

which the pebbles are generally from 1 to 2 feet apart The clusters are separated by 4 or 5 feet of almost barren conglomerate

Some of the boulders are long and narrow—approximately 2 x 6 inches,—where seen on the weathered cross-section of the vertical beds.

On the north side of Rockfish River at the base of the conglomerate, the Lovingston quartz-monzonite outcrops, whereas on the south side of the river an amphibolite dike crops out, which occupies the place of contact between the Lovingston quartz-monzonite and the conglomerate Also near the middle part of the conglomerate is a 75 foot off-shoot of this amphibolite dike There are no amphibolite pebbles in this conglomerate, or pebbles of granodiorite, or of Catoctin schist

This 800 foot conglomerate is named the Rockfish conglomerate, from its type locality on Rockfish River, and is considered to lie at the base of the Lynchburg gneiss of which it is the basal conglomerate It is probable that further work will show that the Rockfish conglomerate extends to the south in the Lynchburg area and to the north into the edge of Albemarle County

Program: E H WATSON of Bryn Mawr College. *The petrology of San Carlos Mountains, Tamaulipas, Mexico*

Discussed by Messrs KEITH, GOLDMAN, STANTON, KING, MILTON, and HEWETT

ARTHUR KEITH *Stratigraphy and structure in western Vermont*

Discussed by Messrs KING, BUTTS, RESSER, and PRINDLE

490TH MEETING

The 490th meeting was held at the Cosmos Club April 27, Vice-President HESS presiding

Program G A COOPER. *A new accent in paleontology*—The recent rise of stratigraphic paleontology has been accompanied by a waning interest in morphological paleontology But on the wave of stratigraphic paleontology has come a renewed activity in the study of all groups of invertebrate fossils This renewed activity has brought with it a flood of new generic names, many of which are poorly defined The logical check on this flood of names is sound morphological study, in which the complete anatomy of the hard parts of the fossils is considered Such a study is necessarily based on excellent specimens or very well prepared fossils

As a basis for such morphological studies chemical and physical methods for the preparation of fossils have been developed which permit the investigator to obtain all points of shell anatomy When fossils are silicified their internal structure may be obtained by etching away the calcareous matrix in dilute acid To obtain the muscle-marks and internal septa the shell may be softened by burning and then picked away so as to reveal the internal mold The dental engine facilitates the preparation of internal characters

By obtaining complete interiors and emphasizing the total morphology of brachiopod shells internal changes due to age may be traced, and perplexing homeomorphs detected In the brachiopods the internal characters give a sound basis for classification, the conservative structures of the dorsal valve defining the families and the variable ventral interior and external ornamentation defining the genera (*Author's abstract*)

Discussed by Mr WOODRING

M N. BRAMLETTE *Origin of the Monterey siliceous rocks of California*

Discussed by Messrs HESS, MANSFIELD, GOLDMAN, ANDERSON, MILTON, RUBEY, LADD, MISER, KING, C. S ROSS, BRIDGE, and K. E LOHMAN

491ST MEETING

The 491st meeting was held at the Cosmos Club May 11, Vice-President HESS presiding.

Informal communications: CHAS. BUTTS presented a geologic map of the Valley of Virginia based largely on field work of his own but which includes also all available published and unpublished material

F G WELLS presented a new physiographic map of Oregon prepared by L. C Raymond of Oregon and pointed out some of the physiographic problems studied in particular by Mr. Raymond

Program W W RUBEY *Alluvial islands their origin and effect upon stream regimen* —Throughout most of their courses in the States of Missouri and Illinois, the Mississippi, Missouri, and Illinois rivers are not meandering streams Their crooked courses are due chiefly to division of the channel by many large alluvial islands Yet, inasmuch as these rivers appear to be neither aggrading nor degrading their channels, the persistence of the islands raises several questions

The islands are larger and more numerous near the mouths of tributary streams This fact, together with the occurrence in the river of small sand bars, larger mud flats and "willow bars," and large wooded islands, suggests that the islands grow up from deposits, dropped by the heavily loaded tributaries and somewhat protected by tree roots The development of islands at tributary mouths shifts the site of deposition riverward and thus the main channel is progressively deflected and the original islands become part of the flood-plain about the tributary mouths Examples are numerous in the region of this crowding of the river channel against the bluffs opposite tributary mouths

The effect of the islands upon stream regimen is a problem distinct from that of their origin Measurements of the channel dimensions near a group of the exceptionally stable islands in Illinois River seem to show that the width and area of the cross-section is perceptibly greater opposite the islands than immediately upstream and downstream Similar relations are also reported in other regions The increased area of cross-section means a decreased velocity opposite the islands But in a graded stream the transporting power must remain constant, despite this decreased velocity, else island-growth once started would increase without limit

The hypothesis is offered that L, the total load transported, may vary as Pv^n, the product of the wetted perimeter of the channel and some power of the velocity The measurements in Illinois River indicate that this power is about $4\frac{1}{4}$, a value in approximate agreement with the average of 171 determinations made by Gilbert The hypothesis may be shown to agree qualitatively with Kennedy's Law for the design of non-silting, non-eroding canals. And, from the expression $Pv^{4.25} \propto L$ and the Chezy formula, the equation, $SX^{1/6} \propto \frac{L^{2/3}}{Q^{5/6}}$, may be derived (where S = slope, $X = \frac{\text{depth}}{\text{width}}$, and Q = discharge) This compares fairly well with a simplification of Gilbert's empirical equation of general stream equilibrium previously given If this suggested inverse relation between wetted perimeter and velocity in a graded stream should be found to hold true generally, it would mean that a stream could only be fully loaded with respect to a particular length of wetted perimeter Widening the same stream so as to increase its perimeter, even though the velocity was somewhat decreased thereby, would increase the total transporting power (*Author's abstract*)

W. S. BURBANK *Relation of Cretaceous and early Tertiary igneous intrusion to structure in Colorado*—Certain effects of the late Cretaceous and early Tertiary structures of Colorado in controlling the intensity and locus of igneous activity are apparent from an inspection of a geologic map showing the distribution of igneous masses and the structural trends The gradual development of these structural trends can be traced in certain events of the historical geology. Some major trends of the Laramide structures coincide with or are parallel to highland trends of late Mississippian to Permian age, and further evidence afforded by unconformities and by Paleozoic sedimentation is believed to show that the outlines of the late Cretaceous and early Tertiary structures were an inheritance, with some modification, from the Paleozoic.

The principal areas of igneous activity of late Cretaceous and early Tertiary age coincide in part with the axial trends of the folding and thrusting of the Laramide revolution, but also equally or even more important centers of intrusion are entirely transverse to the axes of folding Study of the development of tectonic provinces in the State shows that certain kinds of structures, which occupy transitional zones between these provinces, have exerted a dominating control in localizing the transverse zones of igneous activity

These transverse structural zones are probably fundamental flaws in the crust resulting from intermittent shear and tension produced by differential deformation in the bounding provinces They may perhaps be represented in more modern and superficial examples by the shearing and tensional deformation which Brouwer has shown to occur at the zones between major geanticlinal provinces of the Netherlands East Indies Such transverse structures were shown to be persistent throughout several periods of deformation in the Tertiary to Recent formations of the East Indies There is some evidence to suggest that in Colorado conditions were favorable for the incipient division into tectonic provinces as early as late Paleozoic

Many of the larger intrusive centers and the more important ore deposits of the state are situated along or close to this transverse structure Other and probably less important factors that have affected igneous activity and mineralization are the thicknesses of the Paleozoic and Mesozoic sedimentary blanket, and the amount of deformation to which the rocks were subjected preceding and during igneous intrusion Provinces of very thin or only moderately thick sedimentary blankets were characterized by complex volcanism in late Cretaceous and early Eocene time, and by important intrusion and ore deposition of early Eocene age, especially in or near the zone of transverse disturbance On the other hand, geosynclinal provinces of thick sedimentation (15,000 to 20,000 feet or more) that were also affected by strong compressive deformation, were characterized by weak volcanism in late Cretaceous and early Eocene during the period of maximum compression There followed a long cycle of intrusion and volcanism which probably did not reach its climax until late Eocene when compressive forces ceased or became feeble The retarding of volcanism by deformation is comparable to such effects as shown by modern volcanoes of the Netherlands East Indies where deformation has extinguished volcanic phenomena along the crests of the most active geanticlines The ore deposits are less important in regions of maximum thickness and deformation of sediments even where the geosyncline crosses the trend of the transverse igneous belt (*Author's abstract*)

Discussed by Messrs RUBEY, RESSER, and HEWETT.

J F. SCHAIRER and W. H BRADLEY, *Secretaries.*

SCIENTIFIC NOTES AND NEWS

Dr WILLIAM BOWIE, Chief of the Division of Geodesy of the U. S. Coast and Geodetic Survey, has recently been elected Honorary Member of the State Russian Geographical Society.

RECENTLY ELECTED TO MEMBERSHIP IN THE ACADEMY

HERBERT GROVE DORSEY, Principal Electrical Engineer, U S. Coast and Geodetic Survey Instructor of physics at Universities of Maine, Florida and Cornell, research engineer, Western Electric Co, National Cash Register Co, Hammond Radio Research Lab, and Submarine Signal Co. Author of numerous articles on magnetism, expansion, electroculture, electric furnaces, optics, telephony and radio; inventor of several devices including dynamic loud speaker and fathometer

HAROLD EDGAR MCCOMB, Chief, Section of Observatories and Equipment, Division of Terrestrial Magnetism and Seismology, U S. Coast and Geodetic Survey Magnetic observer, Coast and Geodetic Survey, 1909; instructor of physics, University of Nebraska, 1911–1914, magnetic observer, Coast and Geodetic Survey, 1914 Author of numerous papers on general physics, terrestrial magnetism and seismology

WALTER FORD REYNOLDS, Chief, Section of Triangulation, Division of Geodesy, U S Coast and Geodetic Survey. Author of various articles and publications on triangulation surveys in the United States and Alaska. Geodetic computer, Coast Survey, 1907, United States and Canada Boundary Commission, 1908–1911, Coast Survey, 1911; Chief Section of Triangulation, 1924

CLARENCE HERBERT SWICK, Chief, Section of Gravity and Astronomy, Division of Geodesy, U S. Coast and Geodetic Survey. Author of various articles and publications on the gravity, astronomical work and longitude determination of the Coast and Geodetic Survey Hydrographic and gravity surveys 1907–1909, geodetic mathematician, 1910, in charge of editorial work of geodetic publication, 1912, Chief, Section of Gravity and Astronomy, 1924

FRANK N WEIDA, Professor of Mathematics, George Washington University Author of articles relating to mathematical statistics and actuarial science, also text book on analytic geometry Head of mathematics and science depts, St Albans, 1914–1916, assistant in mathematics, University of Chicago, 1916–1917, instructor in mathematics, Univ. of Iowa, 1917–1924; assistant professor of mathematics, Montana State College, 1924–1925; assistant professor of mathematics, Lehigh Univ, 1925–1930, associate professor of mathematics, George Washington Univ 1930

PAUL CLINTON WHITNEY, Chief, Division of Tides and Currents, U. S. Coast and Geodetic Survey Author of various feature articles and publications including Coast Pilots Engaged in hydrographic surveys 1903–1917; magnetic observer on first cruise of non-magnetic yacht "Galilee" of the Carnegie Institution of Washington; Chief, Coast Pilot Section, 1919–1925; in charge of San Francisco Field Station, 1925–1928, Chief, Division of Tides and Currents, 1928

JOURNAL

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VOL. 22 OCTOBER 19, 1932 No. 16, 17

BIOMETRY.—*The growth of mixed populations: Two species competing for a common food supply.*[1] ALFRED J. LOTKA, New York, N. Y.

The general analysis of the growth of mixed populations of any number of species in mutual interdependence *of any kind* which has been given by the writer in prior publications[2] covers many special cases. It is of interest to note how it applies to and readily furnishes the solution of a special case that has since been separately discussed by Volterra,[3] namely that of two species competing for a common food supply.

Volterra, following in this respect well-established lines familiar from prior literature,[4] starts out from the supposition that, in the absence of restraining influences, the rate of growth of a population would be proportional to the existing population thus

$$\frac{dN}{dt} = rN \tag{1}$$

resulting in an exponential (Malthusian) law of population growth; but that the natural limitations of the food supply convert the coefficient r into a diminishing function of N. In the simplest case this would be a linear function, so that we should have

$$\frac{dN}{dt} = r_0 N(1 - phN) \tag{2}$$

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[1] Received August 12, 1932.

[2] Among these may be mentioned Physical Review, 1912, **34**: 235; Proc. American Academy Arts and Sciences **55**: 137, 1920; American Journal of Hygiene **3**. January Supplement; 1923; Elements of Physical Biology, Baltimore, 1925. This last also contains references to the author's other publications relative to this subject.

[3] Memorie della R. Acad. Nazion. dei Lincei 1926 ser. 6, vol. 2, part 3, page 5; *Leçons sur la théorie mathématique de la lutte pour la vie*, Paris, Gauthiers—Villars, 1931, page 9.

[4] See, for example, LOTKA, A. J., Elements of Physical Biology, 1925, page 64.

where ph is a constant which I have written as the product of two constants for reasons that will appear presently Equation (2) is simply the Verhulst-Pearl law of population growth, which, as we know, has been found to fit very acceptably a number of observed examples of population growth.

Now, when two populations compete for a common food supply, Volterra writes, essentially,

$$\left.\begin{aligned} \frac{dN_1}{dt} &= r_1 N_1 \{1 - p_1 (h N_1 + k N_2)\} \\ \frac{dN_2}{dt} &= r_2 N_2 \{1 - p_2 (h N_1 + k N_2)\} \end{aligned}\right\} \tag{3}$$

a system of equations that may be regarded as an almost self-evident extension of the equation (2), except that one may question why the same constants h, k appear in the two equations We shall take up this question later. For the present we shall accept Volterra's original setting. He does not solve his equations, but discusses certain fundamental properties of the functions defined by them. As a matter of fact, by the general method set forth in my prior publications, a solution is readily obtained in series form, and at the same time the conclusions reached by Volterra drop out very readily, together with further information which is not found in his discussion

We will proceed as follows Volterra's equations are of the form

$$\left.\begin{aligned} \frac{dN_1}{dt} &= a_1 N_1 + a_{11} N_1^2 + a_{12} N_1 N_2 \\ \frac{dN_2}{dt} &= a_2 N_2 + a_{22} N_2^2 + a_{21} N_1 N_2 \end{aligned}\right\} \tag{4}$$

Equilibria A stationary state occurs whenever $\frac{dN_1}{dt}$ and $\frac{dN_2}{dt}$ both vanish together. This defines three possible equilibria (to be more exact, stationary states) as follows

$$a.)\ N_1 = 0 \quad N_2 = 0 \tag{5}$$

$$b)\ N_1 = 0 \quad N_2 = -\frac{a_2}{a_{22}} = \frac{1}{p_2 k} \tag{6}$$

$$c)\ N_2 = 0 \quad N_1 = -\frac{a_1}{a_{11}} = \frac{1}{p_1 h} \tag{7}$$

If the coefficients a are constants, there are no other equilibria within real finite values of N_1, N_2.

Stability of Equilibrium: 1. *At Origin* To determine the nature of the equilibrium at the origin ($N_1 = 0$, $N_2 = 0$) we form the characteristic equation of the linear terms in equations (4), that is,

$$\begin{vmatrix} a_1 - \lambda & 0 \\ 0 & a_2 - \lambda \end{vmatrix} = 0 \tag{8}$$

which gives

$$\begin{aligned} \lambda_1 &= a_1 \\ \lambda_2 &= a_2 \end{aligned} \tag{9}$$

Now both a_1 and a_2, from the nature of things, are positive quantities, since the case of real interest is that in which each species is viable separately under the prevailing conditions. Hence both roots of the characteristic equation are positive, and the equilibrium at the origin is unstable.

2. *At Second Equilibrium* To examine the character of the second equilibrium, we transform the equations (4) to a new origin by writing

$$N_1 = N_1 \tag{10}$$

$$n_2 = N_2 + \frac{a_2}{a_{22}} \tag{11}$$

we thus obtain

$$\left.\begin{aligned} \frac{dN_1}{dt} &= \left(a_1 - \frac{a_{12}\,a_2}{a_{22}}\right) N_1 + a_{11}\,N_1^2 + a_{12}\,N_1\,n_2 \\ \frac{dn_2}{dt} &= -\,a_2\,n_2 - \frac{a_{21}\,a_2}{a_{22}} N_1 + a_{22}\,n_2^2 + a_{21}\,N_1\,n_2 \end{aligned}\right\} \tag{12}$$

And, forming the characteristic equation, we find here

$$\begin{vmatrix} \left(a_1 - \dfrac{a_{12}\,a_2}{a_{22}}\right) - \lambda & 0 \\ -\dfrac{a_{21}\,a_2}{a_{22}} & -\,a_2 - \lambda \end{vmatrix} = 0 \tag{13}$$

or, in our original notation,

$$\begin{vmatrix} r_1\left(1 - \dfrac{p_1}{p_2}\right) - \lambda & 0 \\ - r_2 \dfrac{h}{k} & - r_2 - \lambda \end{vmatrix} = 0 \qquad (14)$$

from which it is seen that the equilibrium is stable if, and only if

$$r_1\left(1 - \frac{p_1}{p_2}\right) < 0 \qquad (15)$$

i e., if

$$p_2 - p_1 < 0 \qquad (16)$$

3. *At Third Equilibrium* By the same reasoning we find that the third equilibrium is stable if, and only if

$$p_1 - p_2 < 0 \qquad (17)$$

It will be seen that, except in the special[5] case that $p_2 = p_1$, one of the two equilibria must be stable, the other unstable.

When p_2 is not equal to p_1, it is, for reasons of symmetry, immaterial to which of the two coefficients we ascribe the greater value. Let us, then, write

$$p_2 < p_1 \qquad (18)$$

so that the second equilibrium is the stable one,

i e. $\qquad N_1 = 0 \qquad N_2 = \dfrac{1}{p_2 k}$

The general solution of the system of equations (12) can be written in the form of exponential series

$$N_1 = \Sigma P_{rs} e^{(r\lambda_1 + s\lambda_2)} \qquad N_2 = \Sigma Q_{rs} e^{(r\lambda_1 + s\lambda_2)} \qquad (19)$$

Numerical example For the sake of obtaining a visual presentation of the form of the functions defined by the differential equations (3), (4), (12), and their series solution (19), several numerical examples were worked, of which the following is here selected for reproduction in the accompanying graph Figure 1. The values given to the various

[5] This special case, as Volterra has shown, can be integrated in finite terms It is, however, of minor interest, since such an exact relation between the coefficients p_1 and p_2 represents, in concrete cases, an infinitely improbable condition

constants in this example were arbitrary, except that in order to establish some contact with a concrete case, the values of the exponent λ_1 and the ultimate population N_∞ of the one species were those actually observed in the human population in the United States.

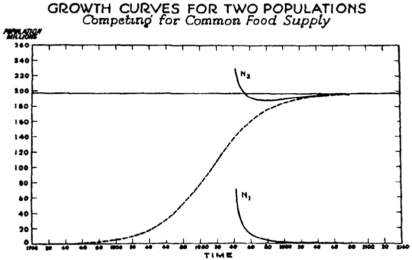


Figure 1

The following is a table of the numerical values[6] of the several constants in this example

h	20	p_1	1/1,315,153,333
k	10	p_2	1/10 × 197,273,000
r_{01}	0 10	λ_1	−0 03134
r_{02}	0 03134	λ_2	−0 05
P_{10}	−986,365	Q_{10}	0 0
P_{01}	+100,000	Q_{01}	29,770
P_{02}	+102 85	Q_{02}	+72 228
P_{03}	+0 13084	Q_{03}	+0 14360
P_{04}	+0 00018325	Q_{04}	+0 00026977
P_{11}	1,706 5	Q_{11}	−712 43
P_{21}	+19 762	Q_{21}	+10 306
P_{12}	−3 1083	Q_{12}	−2 5999
P_{31}	−0 19113	Q_{31}	−0 11656
P_{22}	+0 056626	Q_{22}	+0 053969
P_{13}	−0 0056759	Q_{13}	−0 0069826
P_{20}	+ 491 83	P_{30}	− 24 66
P_{40}	0 1233		

[6] A considerable number of significant figures has been retained in these constants and throughout the computations, in order to furnish an arithmetical check on the series solution (19) This check was obtained by substituting the solution (19) separately in the left hand member and the right hand member of equations (4) or (12) In the absence of a special investigation of the conditions of convergence of the series (19) this arithmetical check is necessary, and was found to be well satisfied within the limits of the curves shown in Figure 1

It will be seen that one of the two populations, in the circumstances to which the graph in Fig. 1 relates, at first diminishes, presently turns the corner, and then increases, approaching a certain straight line asymptotically; the other population diminishes continually and approaches zero. Thus one competitor drives the other out completely. This last point is one of the results given by Volterra[7] who, however, does not give any method for tracing the actual integral curve in detail.

ISOCLINE DIAGRAM FOR TWO POPULATIONS COMPETING FOR COMMON FOOD SUPPLY-

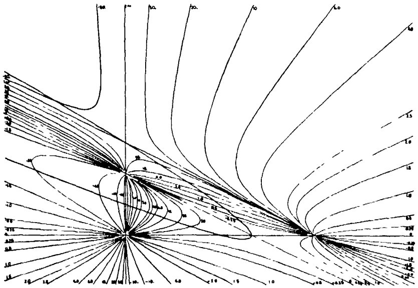


Figure 2

Another graph, which is particularly instructive, is prepared by eliminating the independent variable t from the two equations (4), and writing

$$\frac{dN_1}{dN_2} = \frac{f_1(N_1, N_2)}{f_2(N_1, N_2)} \tag{20}$$

where f_1 and f_2 are quadratic functions of N_1 and N_2. The locus of all

[7] A similar conclusion had been previously reached by J. B. S. HALDANE regarding the competition between two Mendelian phenotypes. Trans. Cambridge Philos. Soc. **23**: 39, 1924.

points at which the integral curves of (20) have a slope s is given by

$$\frac{dN_1}{dN_2} = \frac{f_1}{f_2} = s \tag{21}$$

or

$$f_1 - s f_2 = 0 \tag{22}$$

This defines the *isoclines* as a family of conics, which in point of fact are, in the present case, hyperbolas. The construction has been carried out with the results shown in Figure 2, which exhibits a number of

INTEGRAL CURVES FOR TWO POPULATIONS COMPETING FOR COMMON FOOD SUPPLY-

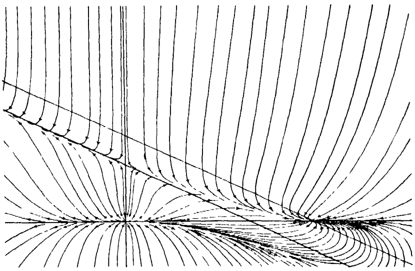


Figure 3

properties of the isoclines. By their aid a map of the family of integral curves has been drawn which is reproduced here in Figure 3 A part of the negative field has been included merely for its geometrical interest, it has, of course, no concrete meaning for our present problem

The following characteristics of this map are particularly noteworthy·

At the origin of N_1, N_2 there is an unstable equilibrium characterized by a stream of integral curves all directed away from the origin (when the time is taken into consideration) This corresponds to the two positive roots of the characteristic equation

There is a second unstable equilibrium at $N_1 = 1/p_1h$, $N_2 = 0$ Here the integral curves approach, then turn away, *avoiding* the equilibrium point This corresponds to two roots λ of opposite sign, of the characteristic equation.

The third equilibrium at $N_1 = 0$, $N_2 = 1/p_2k$, is stable, the integral curves streaming in from all sides This corresponds to the two negative roots λ of the characteristic equation

The locus of the centers of the isocline hyperbolas is a parabola In particular, the center of the isocline for slope ∞ lies at the intersection of the parabola with the axis of N_1, the center of the isocline for slope zero lies at the intersection of the parabola with the axis of N_2

The axes of N_1, N_2 themselves are isoclines, the axis of N_1 corresponding to slope ∞, the axis of N_2 corresponding to slope zero

The second isocline for slope ∞ is parallel to the second isocline for slope 0, the tangent of their inclination to the horizontal being $-\frac{k}{h}$

Of the asymptotes of the isocline hyperbolas, one always has the inclination $-\frac{k}{h}$ to the horizontal The inclination of the other is proportional to the slope s characteristic of the isocline to which it belongs

Let us now briefly consider the implications of Volterra's restriction that $h_1 = h_2$, and $k_1 = k_2$. The physical significance of this restriction is, essentially, that the two species consume one and the same single food material, or, if they consume a mixed diet, that the proportion of each ingredient of the diet which they consume is the same for both species

Now this is a rather narrow and unrealistic restriction Moreover, if we adopt the general method of treating the subject, it is unnecessary The solution applies just as well if $h_1 \neq h_2$ and $k_1 \neq k_2$ Certain significant differences, however, appear in the result Instead of three equilibria in the finite field, there are now four, and one of these may be such that not only one species survives, but both This is more in keeping with the facts of nature, since it is a matter of the most common knowledge that a great variety of species of organisms sharing certain sources of food do live together in essentially stable equilibrium.

It is well known that the Verhulst-Pearl curve of population growth for a single species has been found to fit very acceptably a number of observed cases, among them the growth of the human population of the United States, and also certain laboratory populations of fruit flies and other organisms.

It is perhaps hardly to be expected that concrete examples of the law of growth for two populations here discussed shall be found in nature. There is better prospect of realizing it in a laboratory popula-

tion, though the difficulties of establishing the requisite conditions will here be considerably greater than in the case of a single population. It would be interesting to see the experiment actually made.

But it is possible that the treatment which has here been developed in the analysis of the growth of multiple populations, may find more immediate application in the field of economics. For our variables N_1 and N_2 may be conceived as denoting the size or extent of two (or more) commercial enterprises competing for common sources of supply and for a common market. It will be recalled that Cournot's treatment of the problem of competition has been criticized on the ground that under the conditions of the problem, as analyzed by him, any one competitor who should possess the slightest advantage over the others, would ultimately displace them entirely, and hold the field in absolute monopoly. This criticism, however, is justified only on the assumption that the sources of supply and the markets are equally accessible, in their entirety, to all the competitors In actual fact, with competitors scattered over an area, each has a certain surrounding territory in which he has an advantage over his competitors. In these circumstances the criticism levelled at Cournot falls to the ground.[8] These observations are strongly reminiscent of the facts we observed in the analysis of competition among growing populations, regarding the effect of varying in *some* degree at least the composition of the diet of the competing populations. In the same way two competing commercial firms, though they may sell to the same set of people, will not sell to their several local zones in identical proportions That an application of an analysis similar to that here set forth should present itself as a possibility in dealing with economic systems is only natural, since economic competition is, after all, only a special form of the more general phenomenon of biological competition

[8] Compare H HOTELLING, Economic Journal (London) **41** 41, 1929

GEOLOGY.—*Faults and joints in the Coastal Plain of Maryland*[1] A. L DRYDEN, JR., Bryn Mawr College. (Communicated by W. H. BRADLEY.)

In the various papers on the Coastal Plain formations of the Middle Atlantic States one finds but few references to faulting. McGee[2] thought the rapid change of topography near the fall-line was the result of monoclinal folding or faulting Clark[3] sought to explain

[1] Received July 11, 1932 Published by permission of the State Geologist of Maryland

[2] W J McGEE U S Geol Survey Seventh Ann Rept pp 616-634 1888

[3] W B CLARK, A B BIBBINS, and E W BERRY Maryland Geol Survey, Lower Cretaceous, pp 61, 85, 86 1911

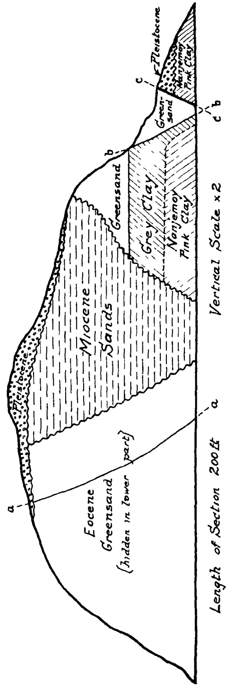

Pleistocene
Miocene Sands
Eocene Greensand (hidden in lower part)
Greensand
Grey Clay
Nanjemoy Pink Clay
Green-sand
Pleistocene
Nanjemoy Pink Clay
a
b
c
Length of Section 200 ft
Vertical Scale x 2

Fig. 1A.

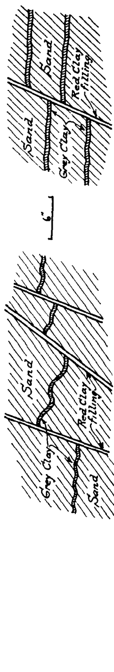

Sand
Grey Clay
Red Clay filling
6"

Fig 1B.

certain "abnormal" altitudes of lower Cretaceous strata by faulting. No direct proof of this faulting was given. Two reports of faulting in the Coastal Plain of New Jersey, with photographs of fault traces, are the only acceptable accounts which have come to the writer's attention.[4,5]

Faulting in the Coastal Plain of Maryland may easily be overlooked. First, there are, as yet, no difficulties in correlation which could be explained by faults of large throw. Faults, then, probably are either small or absent. Second, faults would have no topographic expression, nor would their fault planes be distinguishable in the homogeneous, unconsolidated sands and clays. Clay lenses or indurated layers are not ordinarily present, but generally where such datum planes are found, faults are plainly absent. At one exposure, however, an indubitable fault has been observed, and at two other localities movement along joints or cracks is clearly shown

At a curve on the Crain Highway 3.3 miles south of the southern railroad crossing at Upper Marlboro, Prince George's County, there is exposed a section of Eocene, Miocene, and Pleistocene beds. Figure 1A[6] illustrates the relations found here. There are at least two lines, lettered *a-a* and *b-b*, in this section which may represent faults, or which may be erosional features, though such erosional irregularities have not been noted elsewhere within the Eocene deposits. The line marked *c-c*, however, undoubtedly represents a fault, along which the Pleistocene beds are brought sharply against Eocene material The direction of dip of the fault plane precludes the possibility that slumping has given rise to this relationship. The throw on this fault, however, cannot be more than 15 feet (as is indicated by the thickness of the Nanjemoy clay) and may be as little as 1 or 2 feet. The Pleistocene remnant to the right of the fault has been preserved by downfaulting, as there is none just to the left of the fault.

In a road cut on the steep hill ¾ mile east of Newtown, Newtown-Dentsville road, Charles County, clayey sands of the lower Calvert formation are exposed Where the cut had been recently "dressed" by road employees the relations shown in figure 1B were observed. The "joints" are indicated by bands of red clay about half an inch in thickness which was apparently derived from the overlying Pleistocene deposits In a road cut about 100 yards west of Well's Corner, near

[4] H RIES H B KUMMEL, and G N KNAPP New Jersey Geol Survey **6**: 16 1904

[5] R D SALISBURY and G N KNAPP New Jersey Geol Survey **8**: 79 1917

[6] Miss I M Hellmer of Bryn Mawr College has kindly drawn the accompanying figures

Upper Marlboro, Prince George's County, the same features are shown, except that the clay bands are very thin Such clay bands, resembling joints or cracks, have been observed in the same beds at numerous other localities. Their true nature is problematical. Monroe[7] has described "cracks" which may be similar to the "joints" observed here. The joint lines in this area have a polygonal pattern when seen as traces on a horizontal surface The polygons bounded by these structural lines have from three to five or more sides, and may be 1 to 6 feet in greatest diameter. The joint lines do not cross. Moreover, they were found only in sand beds which, however, contain so much admixed clay that a coherent ball can be formed from the moist material. These structural lines have been traced for about 15 feet vertically. They die out below, and are usually truncated by erosion surfaces above. They may, of course represent cracks due to shrinkage resulting from desiccation, but, for want of conclusive information, their origin remains in doubt.

The foregoing description of small faults and joints seems to have an interesting relation to the structural history of the region.

It is believed (on evidence to be presented later) that the lower Calvert and underlying beds in southern Maryland have been differentially warped. The joints and small faults are possibly related to this movement The upper Calvert (Plum Point Marls) has been tilted without differential warping and in its exposure for 15 miles along the Calvert Cliffs, Calvert County, no small faults nor any of the joints of the type so common in the lower Calvert were observed.

The faults shown in figure 1A are of Pleistocene or Recent age. The movement along the joints of the lower Calvert, as illustrated in figure 1B, may be of Pleistocene age, but at that locality the Pleistocene overlies the Calvert with a sharp, straight-line contact which shows no sign of disturbance. From the evidence available, therefore, it seems more probable that the warping and jointing occurred at the end of lower Calvert time, although the fact that the upper Calvert (Plum Point Marls) is restricted to eastern Calvert County and does not extend into the area discussed leaves the upper limit of such dating open to doubt.

[7] W H MONROE Amer Assoc Petrol Geol Bull 16 · 214 1932

PALEONTOLOGY.—Holopea symmetrica *Hall, genotype of* Holopea *Hall.*[1] J. BROOKES KNIGHT, Yale University. (Communicated by JOHN B. REESIDE, JR.)

In the course of some work on Paleozoic gastropods I have had occasion to run to earth that frequently cited, but imperfectly known, genus *Holopea* Hall. *Holopea* is imperfectly known in two senses; that the knowledge we have of it is not derived from studies of the genotype, so inadequately described and poorly figured by Hall, and that the limits of the genus are so broadly defined as to include much that does not belong to it. I have little to offer to mitigate the latter difficulty except as I am able to clear up the first. The foundations of our knowledge of a genus must be based on the genotype, and it is with the genotype of *Holopea* that this paper will deal. This study will fortunately not alter materially the concept of the genus employed by modern systematists such as Ulrich, Koken, Cossman or Perner, but it is to be hoped that it will give a foundation for that concept that has hitherto been lacking.

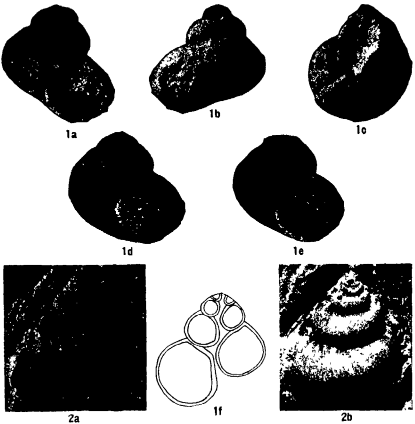
The genus *Holopea* was described by Hall as early as 1847 (1, p. 169) and among the species described at that time was *H. symmetrica* Hall. Hall did not designate a genotype nor seemingly did any of the several authors who discussed the genus before 1889. In 1889, however, S. A. Miller named *H. symmetrica* Hall and *H. obliqua* Hall as genosyntypes (2, p. 405) thus narrowing the field for selection, and Bassler in 1915 (3, p. 625) designated *H. symmetrica* genoholotype. Cossman's designation in 1915 (4, p. 19) of *H. paludiniformis* Hall is, of course, invalid.

The holotype of *H. symmetrica* is deposited in the Hall collection at the American Museum of Natural History, New York, their catalogue No. 751, and Dr. Chester A. Reeds of that museum has been good enough to lend me the specimen for study. Contrary to the condition of most specimens of *Holopea* it is excellently preserved, although most of its base and all of the aperture are buried in matrix. This specimen is shown as Figures 2*a*-*b* of this paper.

The holotype serves to show very clearly the general form and the surface characters of the species though, except by means of preparation that one does not like to undertake on the sole type specimen of the species, the critical apertural and umbilical characters may not be learned from it.

Searching for other specimens which might show the aperture, I

[1] Received August 9, 1932.



Figures 1 *a–f* *Holopea symmetrica* Hall. The T. G. White plesiotype mentioned in the text. *a–e* Various views to show form, ornamentation and apertural characters. *f* Diagrammatic, *camera-lucida* sketch of polished section. Owing to the re-crystallization of the shell-wall, it was difficult to place accurately the boundaries between shell and matrix, except in the last half whorl (lower left) where they are placed with some accuracy. The inner shell boundaries of the other whorls are approximations. The orientation of the section is very slightly oblique and the umbilicus in the last whorl therefore appears a little narrower than if the plane of the section had passed through its center. Yale Peabody Museum No. 13,833.

Figures 2 *a–b* *Holopea symmetrica* Hall. The holotype. Two views to show form and ornamentation. This specimen is the original of Hall's illustration, figure 1, plate 37, volume 1, Palaeontology of New York. Amer. Mus. of Natural History, James Hall Collection, Catalogue No. 751.

All figures × 3. Photographs not retouched.

came across T. G. White's observations on some specimens of unusually good preservation from the Trenton limestone near Trenton Falls, N. Y. (5, p. 85). The preservation of these specimens is excellent and identical in character to that of Hall's holotype, but they do not, as

claimed by White, retain any shell material in its original form nor any trace of pearly lustre. The shells retain the minutest details of surface ornamentation but are wholly and rather coarsely recrystallized internally. They do show a sheen, which White seems to have mistaken for pearly lustre, but this is caused by the contrast of the translucent, recrystallized shell material with the very dark, finely crystalline limestone of the matrix. The coarsely crystalline texture of the shells can be seen in fractures and, even better, in polished sections. Dr. G. Marshall Kay of Columbia University very kindly loaned me all of White's specimens for study and, indeed, presented me with one of them. These specimens were compared carefully with the holotype and one of them was removed from the matrix and cleaned with a needle to expose the base and the aperture. This specimen was photographed, then casts were made to preserve a record of its form and finally an axial section was cut The photographs and a drawing from the section are reproduced as Figures 1*a-f* of this paper

On the basis of studies of the holotype and the T G. White specimens, the species is redescribed in the following terms —

Holopea symmetrica Hall

Holopea symmetrica Hall, 1847, Palaeontology of New York **1**. 170, pl 37, fig 1 Upper, crystalline portions of the Trenton limestone at Middleville, New York White, 1895, Trans N Y Acad Sci **15** 85, Trenton limestone, Trenton Falls, New York Weller, 1903, Geol Surv New Jersey, Paleont **3** 186, pl 12, figs 26, 27, Trenton limestone, Jacksonburg, New Jersey

DIMENSIONS OF *A*, THE HOLOTYPE (FIGS 2 *a-b*) AND *B*, A T G WHITE PLESIOTYPE (FIGS 1 *a-f*)

	A	*B*
Number of whorls	6[a]	6[b]
Height	11 5 mm[a]	11 0 mm[b]
Width	11 25 mm	11 0 mm
Ratio of height to width	1 02	1 00
Ratio of height of body whorl to total	0 79	0 84
Pleural angle	61°	70°

a Estimated on the assumption that 2 apical whorls are missing
b Estimated on the assumption that 3 apical whorls are missing

Moderately small, turbinate gastropods with straight sides, evenly and roundly convex whorl profile and deep sutures, the roundness of the whorl profile continuing uninterruptedly across the base and into the umbilicus, aperture sub-circular, apertural margin only in contact with the previous whorl for a short distance, the ends of the free margins being connected by a thin, parietal inductura, outer lip oblique in side view and only very slightly sinuous, inner lip thin, nearly vertical and slightly reflexed, columella narrowly phaneromphalous, ornamentation, very fine growth lines superimposed on irregular and indistinct transverse undulations. The nucleus has not been observed

It is curious to note that Hall, in his original description, states that the height is much greater than the breadth whereas both the holotype and even Hall's very poor original figure show the height to be only very slightly greater than the breadth. Obviously his statement was founded on a cursory inspection and not on measurements. The apparent relative height of a gastropod shell is very deceptive.

It is unfortunate indeed that the shell structure of none of the specimens is preserved, for if it were it seems very probable that it would show an internal nacreous layer and confirm the conclusion arrived at on other grounds, that the genus should be placed with the Trocho-turbinidae of Koken, an admittedly composite group of family rank used for fossil Trochids and Turbinids which cannot be further distinguished in the light of present knowledge. I would, for the present, include in the Trocho-turbinidae, the Trochonematidae Zittel in which family *Holopea* is placed by Koken and Perner (6, p 213), by Cossman (4, p 19) and by Ulrich (7, p. 1064). There appears to be no justification for placing *Holopea* in the Littorinidae as is done by Perner (8, p 313) and in Zittel's Textbook.

In addition to those curators of collections whose kindness in lending me specimens has been acknowledged in the text, I am indebted to Dr. Ray S. Bassler of the United States National Museum for checking certain references not available to me

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BOTANY.—*Mosses of Northern Guatemala and British Honduras.*[1]

EDWIN B BARTRAM, Bushkill, Pa.

The mosses listed below were collected by Professor H. H. Bartlett during the early months of 1931 in the El Cayo region of western

[1] Received July 8, 1932 This paper is based (in part) upon collections made in a biological survey of the Maya area conducted by the University of Michigan in collaboration with the Carnegie Institution of Washington

British Honduras and in the Petén district of Guatemala [3] The list is an especially interesting one as it is the first record of the mosses from an area that has been a bryological blank on the map of Central America. In a general way the species show a close and very natural relation to those known from the State of Vera Cruz and the Yucatan peninsula but there are also suggestive connections with well known species from the Antilles and northern South America that tend to emphasize the interlocking distribution of the mosses of all the regions bordering the Caribbean Sea.

In the following list the numbers followed by the symbol *B H.* are from the Mountain Pine Ridge in the vicinity of El Cayo, British Honduras while the collections from the limestone areas in the vicinity of Uaxactun, Petén district, Guatemala, are followed by the symbol *P*

FISSIDENTACEAE

FISSIDENS RETICULOSUS Schp 12553 *P* in part

FISSIDENS LEPTOPODUS Card 12155 *P* , 12545 *P* , 12553 *P* , in part, 12643 *P*

While these collections deviate in several minor particulars from the type collection of *F leptopodus* Card the differences do not seem to be important enough to warrant the creation of a new species The Guatemalan plants are generally more freely branched with up to 25 or 30 pairs of leaves, the leaves are less crispate, rather more bluntly pointed and the border of the duplicate blades, in the upper leaves, narrower and less distinct but these characters are all subject to some variation within reasonable limits Evidently the species should be placed in the Section *Semilimbidium* rather than in *Crenularia*

FISSIDENS GARBERI Sull & Lesq 12485 *P*

DICRANACEAE

Campylopus (Palinocraspis) Bartletti sp nov

Sterilis Caespites densi Caulis ad 7 cm longus, simplex vel parce ramosus, dense tomentosus Folia 6 mm longa, sicca erecto-appressa, humida patula, oblongo-lanceolata, concava, in pilum hyalinum denticulatum producta, marginibus planis, superne serrata, costa basi 375μ, dorso sulcata, superne serrulata, breviter excurrente, auriculis distinctis, cellulis suprabasilaribus quadratis ad 25μ latis, marginalibus haud linearibus, cellulis laminae ovalis vel rhomboidalibus

Robust plants in dense tufts or mats, bright yellowish green, slightly glossy. Stems procumbent, up to 7 cm long, flexuose, simple or dichotomously branched above, densely reddish tomentose throughout Leaves uniformly spaced, erect when dry, widely spreading when moist, about 6 mm long, deeply concave, oblong-lanceolate, gradually narrowed to a slender

[3] *Cf* HARLEY HARRIS BARTLETT *A biological survey of the Maya area* Bull Torrey Bot Club 59: 7–20 1932

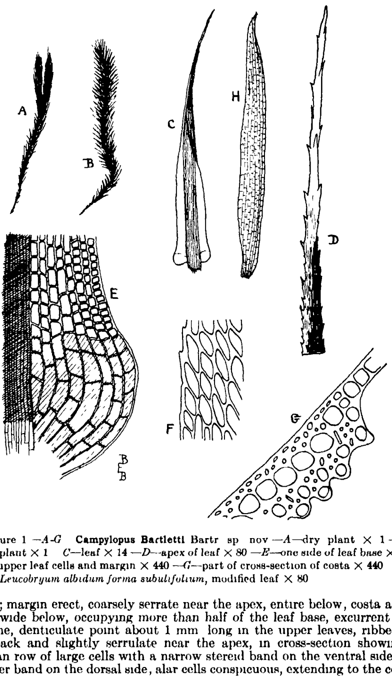

Figure 1 —*A-G* **Campylopus Bartletti** Bartr sp nov —*A*—dry plant × 1 —*B*—moist plant × 1 *C*—leaf × 14 —*D*—apex of leaf × 80 —*E*—one side of leaf base × 160 —*F*—upper leaf cells and margin × 440 —*G*—part of cross-section of costa × 440
H *Leucobryum albidum forma subulifolium*, modified leaf × 80

point; margin erect, coarsely serrate near the apex, entire below, costa about 375μ wide below, occupying more than half of the leaf base, excurrent in a hyaline, denticulate point about 1 mm long in the upper leaves, ribbed on the back and slightly serrulate near the apex, in cross-section showing a median row of large cells with a narrow stereid band on the ventral side and a wider band on the dorsal side, alar cells conspicuous, extending to the costa, usually with reddish walls, cells of the leaf base, just above the alar group, quadrate or short rectangular, up to 25μ wide, smaller but not elongate

toward the margins, gradually becoming smaller and oval-rhomboidal upward, upper cells oval-rhomboidal, 6–7μ wide by 2–3 times as long, distinct to the base of the hyaline point Inflorescense and fruit unknown

Type Pine Ridge, Duck Run, El Cayo District, British Honduras, H H. Bartlett no 12973, April 24, 1931

A very handsome and unique species that naturally suggests a comparison with *Campylopus Richardi* Brid on account of the costal structure and hyaline leaf tips In *C. Bartletti* the color, habit, and particularly the large quadrate basal cells not at all narrowed toward the margins and the shorter cells of the upper leaf blade are strikingly distinct and it is very evident that the two species have little in common. The basal areolation of *C savannarum* (C.M) Mitt is quite similar but the leaves of this species lack the conspicuous hyaline tips

It is a privilege to be able to associate Prof Bartlett's name with such an unusual plant from an area that, heretofore, has been practically unknown bryologically

HOLOMITRIUM CALYCINUM (Hedw) Mitt 11691 *B H*

LEUCOLOMA CRUGERIANUM (C M) Jaeg 11708 *B H* , 11721 *B H* , 11735 *B H.*

LEUCOBRYACEAE

OCTOBLEPHARUM ALBIDUM Hedw 11228 *B H* , 11692 *B H* , 12297 *P*

OCTOBLEPHARUM CYLINDRICUM Schp. c fr 12972 *B H*

Mr Williams credits this species to Jamaica[3] *on the basis of a single,* rather dubious specimen. The collection from British Honduras is in perfect fruiting condition and confirms the occurrence of the species in North America without any question

OCTOBLEPHARUM PULVINATUM (D & M) Mitt 12030 *B H* , 12610 *P*

OCTOBLEPHARUM MITTENII Jaeg 11641 *B H*

In addition to the differences previously mentioned[4] this species will be distinguished from *O erectifolium* Mitt by the lamina cells of the leaf base in two layers The upper part of the leaf, when viewed from either surface, shows a distinct median line, 2–4 cells wide, due to the thickening of the leaf in this area

LEUCOBRYUM ALBIDUM (Brid) Lindb 11634 *B H*

LEUCOBRYUM ALBIDUM (Brid) Lindb forma subulifolium 11690 *B H* , 12729 *P* Folia superiora subulata congesta

These two collections represent a peculiar form with the upper leaves subulate and densely crowded Collections from Mexico and Costa Rica show plants with a similar tendency but not nearly so conspicuous as in 11690

[3] N A Flora **15**, part 2 161 1913

[4] Contrib U S Nat Herb **26**, part 3 72 1928

where the modified upper leaves, which probably serve the purpose of vegetative reproduction, are abundant enough to give the tufts a peculiar silky appearance entirely foreign to the typical plants The plants bearing these apical clusters of modified leaves are in no way different from the normal plants with which they are associated and evidently represent only a minor variant

CALYMPERACEAE

SYRRHOPODON INCOMPLETUS Schwaegr 12031 *B H.*, 12085 *B H* ; 12250 *P.*; 12488 *P*

CALYMPERES LONCHOPHYLLUM Schwaegr 11738 *B H* , 12441 *P* , 12472 *P* , 12636 *P*

As far as I know this species has never been actually recorded from Central America Prof Bartlett's collections are ample and generally well fruited so that it would appear that the species is not at all uncommon in this area The plants in the above collections show the leaves uniformly without teniolae and rather shorter than average plants from the Antilles and Venezuela but the consistently short stems, less than 5 mm , indicate that they should be referred here rather than to *C Levyanum* Besch

POTTIACEAE

BARBULA CRUGERI Sond. 12543 *P*

DESMATODON GARBERI Lesq. & James 12541 *P*

FUNARIACEAE

FUNARIA CALVESCENS Schwaegr 11851 *B H*

BRYACEAE

BRYUM ANDICOLA Hook 11898*a B H*

RHODOBRYUM BEYRICHIANUM (Hsch) Par 12604 *P* , 12636 *P*.

ORTHOTRICHACEAE

MACROMITRIUM MUCRONIFOLIUM (Hook. & Grev) Schwaegr. 12315 *P.*

MACROMITRIUM PENTASTICHUM C M 11692*a B H* , 11693 *B H*

MACROMITRIUM CIRRHOSUM (Hedw) Brid 11734 *B H*

SCHLOTHEIMIA MOHRIANA C M 13047 *B H*

HELICOPHYLLACEAE

HELICOPHYLLUM TORQUATUM (Hook) Brid 13136 *B H*

RHACOPILACEAE

RHACOPILUM TOMENTOSUM (Hedw) Brid 12251 *P* , 12516 *P.*, 12646 *P.*, 12714 *P* , 12716 *P* , 12730 *P* , 12749 *P*

LEUCODONTACEAE

LEUCODONTOPSIS FLORIDANA (Aust) E G. Britt 12044 *B H* , 13094 *B H*.
PSEUDOCRYPHAEA FLAGELLIFERA (Brid) E. G Britt 12493c *P*

PTEROBRYACEAE

ORTHOSTICHOPSIS TETRAGONA (Hedw) Broth 11736 *B H* , 12324 *P*.; 12442 *P*.

PIREELLA CYMBIFOLIA (Sull) Card 12472a *P* , 12493a *P*

No 12493a shows the following sporophyte characters seta reddish, erect, flexuose, 8–10 mm long, smooth, capsule erect, ovoid-cylindric, brown, 2–2 25 mm long by 0 5 mm wide, slightly narrowed at the mouth, spores brownish, papillose, 22–25μ in diameter, peristome, lid and calyptra not seen (capsules all old and deoperculate)

PIREELLA PACHYCLADA (Ren & Card) Card 12265 *P* , 12486 *P*

These collections seem to agree perfectly with the description of the type collection from Yucatan The following sporophyte characters are taken from several fruiting plants found in no 12486 seta erect, reddish, flexuose, smooth, 4–5 mm long, capsule erect, oblong-cylindric, up to 2 5 mm long by 0 35 mm wide, brownish, slightly narrowed above (capsules old and deoperculate)

Upon comparing this species with *P Mariae* (Card), of Costa Rica, it will be noticed that, in addition to the differences in vegetative characters, the size and shape of the respective capsules are thoroughly distinctive and that the setae of *P pachyclada* are smooth throughout

METEORIACEAE

PAPILLARIA NIGRESCENS (Hedw) Jaeg 12482 *P* , 12498 *P* , in part , 13046 *B H* , 13047a *B H*

METEORIOPSIS PATULA (Hedw) Broth 12484 *P* , 12670 *P* , 12671 *P*., 12728 *P*

NECKERACEAE

NECKEROPSIS UNDULATA (Palis) Broth 12265a *P* , 12493b *P*
NECKEROPSIS DISTICHA (Hedw) Fleisch 12452 *P* , 13146 *B H*

HOOKERIACEAE

CALLICOSTELLA PALLIDA (Hsch) Jaeg 11845 *B H* in part, 12597 *P* in part, 12598 *P* , 12616 *P* in part

FABRONIACEAE

HELICODONTIUM TENUIROSTRE Schwaegr 13135 *B H*

THUIDIACEAE

HAPLOCLADIUM MICROPHYLLUM (Hedw.) Broth. 12616 *P*.
THUIDIUM INVOLVENS (Hedw.) Mitt. 12251 *P*, 12255 *P*, 12259 *P*, 12260 *P*.; 12480 *P* in part, 12498 *P* in part, 12597 *P*.

SEMATOPHYLLACEAE

RHAPHIDORRHYNCHIUM SUBSIMPLEX (Hedw.) Broth. 11739 *B H*.
SEMATOPHYLLUM CAESPITOSUM (Hedw.) Mitt. 13150 *P*.
SEMATOPHYLLUM LOXENSE (Hook.) Mitt. 11845 *B H*, 11846 *B H*, 11847 *B H*.
TAXITHELIUM PLANUM (Brid.) Mitt. 11739 *B H* in part, 12252 *P*. in part, 12272 *P* in part, 12490 *P* in part, 12452 *P*. in part, 12516 *P* in part; 12597 *P* in part, 12598 *P* in part, 12616 *P* in part, 12729 *P*. in part.

HYPNACEAE

VESICULARIA AMPHIBOLA (Spr.) Broth. 12597 *P* in part.
MICROTHAMNIUM THELISTEGUM (C. M.) Mitt. 11720 *B H*, 12252 P, 12255 *P* in part, 12258 *P*, 12259 *P* in part, 12272 *P*, 12314 *P*, 12480 *P*, 12498 *P*, 12499 *P*, 12517 *P*, 12539 *P*., 12713 *P*, 12716*a* *P*.

ZOOLOGY.—*The male of the nematode species*, Neotylenchus abulbosus, *Steiner, and its sexual dimorphism*.[1] G. STEINER and EDNA M. BUHRER, Bureau of Plant Industry.

The male of the species *Neotylenchus abulbosus* Steiner[2] was not known until recently, when a single specimen was found among numerous larvae and females parasitizing a diseased carrot grown in Sweden and intercepted at the port of Philadelphia by the Plant Quarantine and Control Administration inspectors. The shape and general structure of this single specimen seem to exclude any other relationship than that with the aforementioned species.

This male is slightly smaller and more slender than the average females. The annulation of the cuticle is extremely faint; only on the bursa is it more evident (Fig. 1, B). In general, this male somewhat resembles that of *Tylenchus dipsaci*, just as there is also a resemblance between the mutual females. The front of the head end shows the 8 sectors typical of the female, likewise, the esophagus has no bulb. The most interesting feature, however, is the almost completely vanished spear. As depicted in fig. 1, A only the rodlike cuticularized

[1] Received July 19, 1932.
[2] STEINER, G. Neotylenchus abulbosus, *n. g.*, *n. sp.* (*Tylenchidae, Nematoda*) *the causal agent of a new nematosis of various crop plants*. This JOURNAL **21**: 536–538. 1931.

supports of the lip region remain of the whole apparatus as found in the female and the larva. The shaft of the spear, the conical point, and also the basal knobs have faded; the posterior end is faintly marked by the dim outlines of protrudor muscles.

This case seems to be analogous to that of *Tylenchus similis* where the male also differs from the female and larva in the remarkable reduction of the spear Perhaps this obliteration indicates that these males cease to feed in the adult stage either because they are not functional (in the case of *Neotylenchus abulbosus* (?)) or because they copulate but once during their life (perhaps in *Tylenchus similis*). Both forms are evidently endoparasites of plants Two remarkable larvae of *N abulbosus*, perhaps males of the preadult stage, were recently found in strawberry plants from California which were affected with "yellows" or "xanthosis" and which often harbor this nema. Their spear had vanished as in the male specimen here described, indicating an early loss or even a complete absence of the spear also in the larval stages of the male

As to the copulatory apparatus, the present male displays a well developed bursa, reaching from in front of the spicula to the tail end, which is pointed and set off (Fig. 1, B). No bursal rays or ribs were seen. The spicula are remarkably small but very similar in form to those of *T. dipsaci*. An extremely small lineate gubernaculum was also seen.

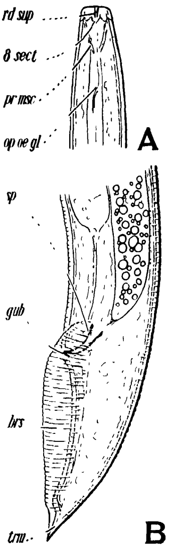

Fig 1 —*Neotylenchus abulbosus*, male A —Head end, *rd sup*, rodlike supports, *8 sect*, 8 sectors of the head, *pr msc*, protrudor muscles of the spear, *op oe gl*, opening of esophageal gland B —Tail end, *sp*, spicula, *gub*, gubernaculum, *brs* bursa, *trm*, setoff portion of tail × about 1070

$$\text{Measurements} \ \frac{- \quad (?) \quad 8.9 \quad \text{M} \quad 94.9}{- \quad (?) \quad 2.0 \quad 2.6 \quad 2.0} \ 0.74 \text{ mm.}$$

It may be remarked that *Neotylenchus abulbosus* shows a close resemblance to *Hexatylus viviparus* of Goodey 1926 [3,4] By correspondence, Dr. Goodey called attention to this similarity, thereby causing a detailed re-examination of our material and indirectly the finding of the male specimen If, as stated in its description, *Hexatylus* has a head divided into only 6 sectors and a spear with 6 basal knobs instead of only 3, then *Neotylenchus abulbosus* and *Hexatylus viviparus* are different. The male of *Hexatylus* is not known

[3] GOODEY, T Hexatylus viviparus *gen et sp nov , a nematode found in a diseased potato tuber* Jour Helminthol **4**. 27–30 1926

[4] GOODEY, T *A further note on* Hexatylus viviparus *Goodey, 1926* Jour Helminthol **4**: 183–184 1926

ZOOLOGY —*Two new cacomistles from Mexico, with remarks on the genus* Jentinkia.[1] E. W NELSON, Smithsonian Institution, and E. A. GOLDMAN, Biological Survey

The generic name *Jentinkia*, proposed by Trouessart (Catal. Mamm., Viv Foss [suppl], 1904, p 184) has not been generally accepted for the tropical cacomistles typified by the animal currently recognized as *Bassariscus sumichrasti* Saussure. Some of the characters of the genus have been mentioned by various authors, and the external features have been dealt with at some length by Pocock, in a discussion of the Procyonidae (Proc Zool. Soc. London, 1921, pp 389–422) He says (p. 392) "This Cacomistle is sometimes admitted as a subgenus of *Bassariscus.* I have provisionally quoted it as a distinct genus, the material available being insufficient to establish the absolute constancy of the differences in the feet observable between [*Bassariscus*] *astutus* and *sumichrasti.*"

A study of fourteen skins and skulls of *sumichrasti*, of ages varying from very young to quite old, and over one hundred similar specimens of *Bassariscus astutus* leads us to agree with Pocock that *Jentinkia* should be accorded full generic rank.

Jentinkia compares with *Bassariscus* as follows

Jentinkia	*Bassariscus*
Muzzle and feet distinctly blackish, tail with light rings becoming obsolescent toward end	Muzzle and feet grayish, tail with light rings distinct throughout its length
Pelage finer, softer, and more lax	Pelage coarser and stiffer

[1] Received August 22, 1932, revised September 9, 1932

Ears more broadly and evenly rounded	Ears more narrowly rounded, the margins somewhat produced antero-externally
Second, third, fourth, and fifth digits of fore and hind limbs naked on lower surface behind digital pads, which are narrower, more elongated	Second, third, fourth, and fifth digits of fore and hind limbs densely hairy on lower surface behind and around digital pads, which are broader, more rounded
Claws longer, more strongly curved, more compressed, non-retractile	Claws shorter, straighter, less compressed, retractile
Maxillary portion of zygoma placed farther back, the posterior border in plane of second upper molars, or point of contact between these and first upper molars	Maxillary portion of zygoma placed farther forward, the posterior border in plane of first upper molars
Foramen ovale opening more directly forward	Foramen ovale opening more directly downward
Cusps in large molariform teeth less trenchant, more rounded, with lower, less prominent connecting ridges	Cusps in larger molariform teeth more trenchant, with higher, sharper connecting ridges
Upper carnassial triangular in outline, without a postero-internal cusp	Upper carnassial irregular in outline, with a prominent postero-internal cusp
Posterior lobe of upper carnassial and anterior lobe of lower carnassial more weakly developed	Posterior lobe of upper carnassial and anterior lobe of lower carnassial more strongly developed
Cutting edges of first and second upper incisors, of permanent series, distinctly trifid	Cutting edges of first and second upper incisors, of permanent series, normally smooth

Jentinkia inhabits the great forests of tropical Middle America, its range meeting that of *Bassariscus* along the eastern slopes of the Mexican highlands It is much more arboreal in habits than the latter, which is at home along cliffs and rocky ledges and spends much time upon the ground The sharp, curved, non-retractile claws of *Jentinkia*, adapted for clinging, appear to be associated with its arboreal life, while those of *Bassariscus*, with cat-like retractility, are better fitted for progression among rocks

The genus comprises a single species which is subdivisible into closely allied geographic races as follows

Jentinkia sumichrasti sumichrasti (Saussure) Mirador, Vera Cruz, Mexico.
Jentinkia sumichrasti variabilis (Peters) Coban, Guatemala

Jentinkia sumichrasti campechensis, subsp. nov Apazote, Campeche, Mexico.
Jentinkia sumichrasti notinus (Thomas) Boquete, Chiriqui, Panama.

B[assaris] astuta was first described by Lichtenstein (Abhand Akad. Wissensch Berlin, 1827, p 119, 1830) in a discussion of the application of names of Mexican mammals treated by Hernandez (Rerum Medicarum Novae Hispaniae Thesaurus, 1651, tract 1 [appendix]) The name appears to be based primarily upon a specimen collected by Deppe who worked extensively in southeastern Mexico Reference was also made to the cacomistle of the Mexican Indians, currently recognized as *Bassariscus astutus*, which ranges as a species throughout the plateau region of Mexico and northward into the United States In 1831 Lichtenstein (Isis, vol 24, p 513) again described the animal and assigned it to a "Habitat in Mexico" In response to an inquiry Dr Hermann Pohle has written us that the specimen mentioned was received from Deppe in 1826 "aus Mexiko (wahrscheinlich Stadt Mexiko)," and mounted with the skull inside still exists as number 1081 in the Berlin Museum We regard specimens from the vicinity of the Valley of Mexico as typical

Bassariscus albipes Elliott (Field Columb Mus , publ 87, zool ser , vol. 3, p 258, Dec 1903) was described from a single specimen obtained "near Vera Cruz, State of Vera Cruz, Mexico" The label, however, shows that the type was taken at Xico, which is near Jalapa, Vera Cruz, on the eastern slope of the highlands *B albipes* is identical with typical *B astutus*

Western Mexico is inhabited by a smaller subspecies, here described, together with a new form of *Jentinkia*

Jentinkia sumichrasti campechensis, subsp nov

Campeche Cacomistle

Type —From Apazote (near Yohaltun), central Campeche, Mexico No. 108291, ♂ adult, U S National Museum (Biological Survey collection), collected by Nelson and Goldman, January 2, 1901 Original No 14386, X catalogue number 10240

Distribution —Tropical lowland forests of the Yucatan Peninsula, probably ranging into northern Guatemala and British Honduras

General characters —Very similar to *Jentinkia sumichrasti sumichrasti* of the mountains of Vera Cruz, but considerably smaller, skull smaller, more delicate in structure. Similar in color to *Jentinkia sumichrasti variabilis* of the mountains of south-central Guatemala, but much smaller

Color —*Type* Ground color of upper parts in general buffy grayish extensively overlaid with black, the black-tipped hairs most abundant on head, nape, and median line of back, sides of head and face, including muzzle all around blackish, interrupted by dull whitish markings over and under eyes, under parts and inner surfaces of limbs light ochraceous buff, ears externally brownish black to the distinct white margins, thinly clothed internally with whitish hairs, fore and hind feet and toes distinctly blackish, tail with five gray rings on basal half succeeded by three obsolescent gray rings, alternating with black rings, becoming clear black above and below toward tip In other

specimens eight or nine gray tail rings vary in distinctness, tending to become invisible toward the end which is always black. A very young individual is similar to adults, but the ears are pure white on distal half.

Skull.—Similar to that of *J. s. sumichrasti*, but decidedly smaller, less massive, rostrum more slender, audital bullae relatively smaller, dentition variable but usually lighter. Differing from that of *J. s. variabilis* mainly in much smaller size.

Measurements.—*Type.* Total length, 905 mm.; tail vertebrae, 500; hind foot, 92. An adult male topotype: 863; 474; 87. Two adult females from La Tuxpeña, Campeche: 891, 880; 459, 455; 82, 77. *Skull* (type): Greatest length, 90; condylobasal length, 84.7; zygomatic breadth, 59.8; breadth of rostrum (over root of canine), 17.6; interorbital breadth, 18.5; upper canine-molariform toothrow (alveoli), 32.8; upper carnassial, crown length (outer side), 6.7; crown width, 5.2.

Remarks.—*Jentinkia sumichrasti campechensis* is characterized mainly by small size. It is an outlying peninsular form, but is contiguous to and doubtless intergrades with both *J. s. sumichrasti* and *J. s. variabilis*.

Specimens examined.—Total number, 8, as follows:

CAMPECHE: Apazote (type locality), 2; La Tuxpeña, 5.

YUCATAN: Buena Vista Xbac, 1.

Bassariscus astutus consitus, subsp. nov.

Michoacan Cacomistle

Type.—From La Salada, 40 miles south of Uruapan, Michoacan, Mexico. No. 126162, ♀ adult, U. S. National Museum (Biological Survey collection), collected by Nelson and Goldman, March 16, 1903. Original No. 16151.

Distribution.—Central Michoacan and Jalisco, and northward through the Sierra Madre to southern Sinaloa, passing farther north into *Bassariscus astutus arizonensis*.

General characters.—Closely allied to *Bassariscus astutus astutus*, of the vicinity of the Valley of Mexico, but decidedly smaller, pelage shorter, general color about the same, but toes of hind feet grayish, mixed with dusky (usually white in *astutus*); skull slightly different. Similar in size to *B. a. flavus* of Texas, color much grayer, less ochraceous buff, cranial characters distinctive. Differing from *B. a. arizonensis* of Arizona, in considerably larger size, and well-marked cranial details; color similar.

Color.—*Type.* Ground color of upper parts in general buffy grayish, the top of head, middle of neck and back overlaid with black, the dark hairs thinning out along sides and over thighs, rump suffused with pale ochraceous buff; face, including sides of muzzle and cheeks blackish, relieved by whitish markings over and under eyes; throat, inner sides of limbs and inguinal region white; under side of neck, chest, and area across abdomen light buffy; ears blackish on basal half externally, becoming silvery grayish toward tips, and thinly clothed with grayish hairs internally; outer sides of forearms mixed buffy grayish and dusky; fore feet buffy grayish, hind feet grayish above, mixed with dusky over metatarsus and toes, the soles blackish posteriorly; tail with eight alternating black and white rings and a black tip.

Skull.—Very much like that of *B. a. astutus*, but distinctly smaller, braincase relatively narrower; rostrum and frontal region high as in *astutus*, dentition about the same. Compared with *B. a. flavus* the skull is of about the

same size but differs in important features as follows: Braincase relatively narrower, more elongated, frontal region higher, less sloping anteriorly, rostrum heavier (broader and deeper) Larger than that of *B. a arizonensis*, with a higher but relatively narrower frontal region, zygomata more widely spreading, braincase relatively narrower, more elongated, instead of rounded and inflated, rostrum less tapering

Measurements—*Type* Total length, 755 mm.; tail vertebrae, 380, hind foot, 78 An adult male topotype· 793, 400; 80 *Skull* (type) Greatest length, 82 3, condylobasal length, 78 3, zygomatic breadth, 50 2, breadth of rostrum (over root of canine), 15, interorbital breadth, 16 2, upper caninemolariform tooth row (alveoli), 31, upper carnassial, crown length (outer side), 7 2, crown width, 4 8

Remarks—*B a consitus* is more closely related to *B a astutus* than to any of the other known forms, although in size it more nearly approaches *B a. flavus* The specimens available indicate a range extending down from the mountains into tropical parts of western Mexico, while typical *astutus* occupies the higher plateau region to the east

Specimens examined—Total number, 8, as follows

JALISCO Ameca, 1, Bolaños, 1, Ocotlan, 2

MICHOACAN La Salada (type locality), 3

SINALOA· Plomosas, 1

ZOOLOGY—*A new pocket mouse from Southern Arizona*[1] E. A. GOLDMAN, Biological Survey

The descriptions of two new subspecies of *Perognathus amplus* were recently published (this JOURNAL **22**: 386–388). They were based on a study, by the writer, of 68 specimens referable to the species, from 20 localities in Arizona While the paper was in press 23 additional examples were received, unexpectedly, from the Tucson region, in the southeastern part of the State These present differential characters that seem to warrant the recognition of still another new geographic race The material now available proves that *P. amplus*, known originally from a single individual only, ranges throughout most parts of the Lower Sonoran Zone in Arizona; but the species has not yet been recorded beyond the borders of the State.

Perognathus amplus taylori, subsp nov

Pima Pocket Mouse

Type—From Santa Rita Range Reserve (near Northeast Station), 35 miles south of Tucson, Pima County, Arizona (altitude about 4,000 feet) No 250533, ♀ adult, U S National Museum (Biological Survey collection), collected by Walter P Taylor, August 3, 1930 Original No 1899

Distribution—Desert region of southern Arizona and probably northern Sonora, east of the range of *Perognathus amplus rotundus*

[1] Received August 22, 1932

General characters.—A small, richly colored subspecies, with a delicately formed skull. Closely allied to *Perognathus amplus amplus* of central Arizona, but smaller and of slenderer proportions, color about the same; cranial details, especially the smaller mastoids, distinctive, tail longer than head and body, slightly crested near end and tufted as in *amplus*. Distinguished from *P. a. rotundus* of southwestern Arizona, by smaller size, darker, richer pinkish buffy coloration, and less swollen mastoids. Size about as in *Perognathus amplus pergracilis* of northwestern Arizona, south of the Grand Canyon, but color distinctly darker pinkish buff, skull differing in detail.

Color.—*Type* (acquiring fresh pelage): Upper parts near pinkish buff (Ridgway, 1912), purest on cheeks, shoulders, flanks and outer surfaces of thighs, the top of head and back finely lined with black, under parts, fore limbs, and hind feet white, ears pinkish buffy externally, except anterior fold which is dusky, sparsely clothed internally with blackish hairs, and distinctly edged with white near posterior base, tail thinly haired, grayish above, whitish below, becoming brownish or dusky on crest and terminal tuft. Adults in somewhat worn summer pelages are of a deeper, richer color than the type, the general tone above between pinkish buff and cinnamon buff.

Skull.—Similar in general to that of *P. a. amplus*, but decidedly smaller, mastoids less inflated, the sides more convergent posteriorly (sides more nearly parallel, owing to lateral expansion posteriorly in the type of *amplus*), dentition about the same. Size much smaller than *P. a. rotundus*, with mastoids less swollen and not bulging above level of outer borders of parietals as in that form. Similar in size to *P. a. pergracilis*, but frontals broader, interparietal narrower, mastoids and dentition about the same.

Measurements.—*Type*: Total length, 155 mm.; tail vertebrae, 84; hind foot, 20. Average of 10 adult topotypes: 140 (123–150); 72 (60–80); 18.7 (17–20). *Skull* (type): Occipitonasal length, 23.5; greatest breadth (across audital bullae at meatus), 13.7; zygomatic breadth (posteriorly), 12.2; interorbital breadth, 5.3; length of nasals, 9.2; width of nasals (in front of incisors), 2.3; interparietal, length, 3; width, 3.2; maxillary toothrow (alveoli), 3.4.

Remarks.—*Perognathus amplus* as a species presents a rather unusual range of geographic variation in combination of details of form and feature, within a limited area, even for a member of a group so subject to diversification as the pocket mice. While the several races are obviously very closely allied the distinctive characters are quite constant. A specimen from Gila Bend is somewhat larger and in rather pale color indicates gradation toward *P. a. rotundus*. The collector found *P. a. taylori* inhabiting the "creosote" (*Covillea mexicana*) type of vegetation cover.

Specimens examined.—Total number, 27, all from Arizona, as follows: Casa Grande, Pinal County, 1; Continental (Amado Well, 2 miles south), 4; Gila Bend, Maricopa County, 1; Gunsight, Pima County, 1; Papago Well (O'Neill Hills, 8 miles east), Pima County, 1; Range Reserve (35 miles south of Tucson), 19.

ANATOMY.—*Formatio reticularis and reticulospinal tracts, their visceral functions and possible relationships to tonicity and clonic contractions.*[1] WILLIAM F. ALLEN, University of Oregon Medical School.

It is known from embryology that most of the left over cells of the brain stem and spinal cord which are not concerned in the formation of motor root nuclei and purely sensory relay nuclei are utilized in the production of the formatio reticularis. This is a very old structure phylogenetically. It is but little differentiated in the lower vertebrates, where it apparently serves as an effective mechanism which enables these animals to adapt themselves properly to their various inside and outside conditions. In the higher vertebrates there is but little reticular formation in the spinal cord, but considerable in both the median and lateral portions of the medulla, pons and midbrain, where for the most part it exists anatomically in its original undifferentiated state. Reticular formation surrounds or partially surrounds the sensory nuclei of the thalamus, and when considered phylogenetically the nucleus ruber, substantia nigra and other differentiated hypothalamic and midbrain nuclei should probably be considered as specialized derivatives.

Afferent fibers to the formatio reticularis. The hypothalamic nuclei undoubtedly receive important olfactory, thalamic, basal ganglia, cerebral, cerebellar and medullary connections The nucleus ruber and other midbrain nuclei belonging to this system have similar connections and should be stimulated by like impulses Ramón y Cajal has demonstrated many collaterals from the corticospinal fibers distributed to the formatio reticularis of the pons and medulla Pavlow, Busacca, Rasmussen and Le Cocq have found many degenerated fibers in the formatio reticularis of the pons and medulla resulting from lesions in the colliculi and these degenerated fibers were not traceable in the spinal cord below the cervical region. Le Cocq has shown that transecting the spinal cord at the 6th. cervical vertebra resulted in no chromatolysis in the superior colliculi, while large lesions in the medulla were followed by many chromatolytic cells in the motor area of the superior colliculi Hence the descending tract from the superior colliculus is to be regarded as tectobulbar rather than tectospinal. Fibrae fastigiobulbares from the fastigial nucleus of the cerebellum have been described by Russel, van Gehuchten, Luna, Allen (1924) and Bernis and Spiegel going to Deiter's nucleus, where some probably end A large number, however,

[1] Received July 5, 1932

follow the descending vestibular root fibers to be distributed chiefly to the formatio reticularis of the medulla and the median longitudinal bundle. Thomas, Probst, Lewandowsky, Wallenberg, van Gehuchten, von Monakow, Luna and the writer (1924) have called attention to a descending brachium conjunctivum, which leaves the main brachium conjunctivum immediately after decussation This tract for the most part follows dorsally to the median lemniscus and terminates in the reticular formation of the pons and medulla. Attention is also directed to the possible importance of numerous branches of the brachium conjunctivum to the hypothalamic region. These fibers were described by Probst (1901) and confirmed by the writer (1924). Van Gehuchten and the writer have found numerous branches of the brachium conjunctivum ending in the formatio reticularis of the midbrain and in the oculomotor nuclei. Presumably all of the sensory cranial nerve fibers communicate in one way or another with the reticular formation. The many vestibular connections to the undifferentiated and differentiated formatio reticularis, described by Muskens and others, should be of considerable significance. They are said to arise from the triangular, Deiter's and Bechterew's nuclei, to go by way of the posterior longitudinal bundle, and to be associated with forced movements. Muskens describes a crossed and an uncrossed fasciculus vestibulo-mesencephalicus to the interstitial and posterior commissural nuclei and an uncrossed fasciculus vestibulo-tegmentalis lateralis (and possibly a medialis) to the tegmentum He also describes efferent tracts from the interstitial and posterior commissural nuclei to the medulla and spinal cord and suggests possible connections from the corpora striata to the posterior commissural nuclei. The writer's experiments (first paper 1927) indicated that fibers from the solitary tract and commissural nuclei (terminal nuclei for the sensory fibers of the VII, IX and X cranial nerves) do not go directly to the spinal cord, but are relayed by way of the formatio reticularis.

Efferent fibers from the formatio reticularis Some of these fibers obviously synapse with the various motor root nuclei of the brain stem. According to Kohnstamm, Tschermak, von Bechterew, van Gehuchten and Papez the descending fibers from the reticular formation may or may not cross in the medulla. Van Gehuchten, Probst and Papez have described ventral and lateral reticulospinal tracts in the spinal cord. The former run in the ventral column and the latter approximate the gray in the lateral column. The reticulospinal tracts have received some attention as extra pyramidal tracts on

account of their cerebral connections. The course of the rubrospinal tract in the brain stem and lateral column of the spinal cord is well known

Possible functions of the formatio reticularis: All physiologists agree that the medulla contains centers for altering the rate of the pulse and the level of blood pressure. Ranson and Billingsley have located vaso constrictor and vaso dilator points in the medulla not far from the area postrema Transecting the spinal cord in the upper cervical region greatly reduces arterial pressure for some time. Many investigators including Brown-Séquard, Gad and Marinesco, Kohnstamm and others have placed the medullary respiratory center within the limits of the formatio reticularis. Lumsden has located 3 different respiratory centers in the medulla and pons, the stimulation of which affects respiration differently. Spiegel and Enghoff place the respiratory center in the rhombencephalon. They state that stimulation or injury to this center results in the Cheyne-Stoke or Biot type of respiration Other regions such as corpora quadrigemina, nucleus ruber and tegmentum which may produce an arrest of respiration from stimulation are considered only as reflex areas

Many investigators from Karplus and Kreidl to Beattie have emphasized the importance of certain hypothalamic nuclei as centers for visceral and humoral impulses Beattie thinks this area has both sympathetic and parasympathetic centers. The following investigations also demonstrate that lower levels of the formatio reticularis may have like functions Spiegel and Démétriades have observed that intestinal movements caused from vestibular stimulations were intensified after transecting the midbrain Ingram, Ranson and Hannet obtained pupillary dilation from stimulation of the reticular formation of the mesencephalon and pons The writer (1931) showed that the slowed pulse followed by a bigeminal pulse, the rise in blood pressure and the arrest of respiration caused from stimulation of the trigeminal nerve by insufflation could readily be evoked when the brain stem was sectioned below the diencephalon In addition there was probably an increased output of adrenalin. The writer's work (1927 and 1931) indicates that the respiratory and vascular changes elicited from stimulation of the cerebral motor cortex and the superior colliculus are not conducted within the spinal cord by the pyramidal and rubrospinal tracts or by a "tectospinal tract" from the colliculus, but by relays to the reticulospinal tract. It was further demonstrated (second paper 1927) that the well known rigidity and clonic contractions elicited from stimulations of the superior colliculus were depend-

ent on the integrity of the median portion of the lateral columns of the spinal cord as well as the ventral columns, a region traversed by the reticulospinal fibers.

Possible relationships of the formatio reticularis to the cerebellum and to muscle tone: In Luciani's classical experiments of removal of one half of the cerebellum, the second stage was described as one of marked weakness on the side of the lesion. Ingvar has reported that destruction of the anterior lobe of the cerebellum results in a tendency for the animal to fall forward, while obliteration of the posterior lobe causes the animal to fall backward, and a lesion in one hemisphere is followed by a tendency to fall to that side. Miller and Laughton have shown that faradic stimulation of the basal nuclei of the cerebellum of a decerebrate animal (red nucleus intact) increases the tone of the flexor muscles and decreases the tone of the extensors and is followed by a rebound. Several years earlier Bremer obtained similar results from stimulation of the palaeo-cerebellar cortex In addition he obtained an alteration of certain rhythmic movements of progression which may be present in decerebrate animals. Some unreported experiments by the writer have shown that injection of a few drops of sodium citrate into the cortex of the cerebellum evokes rigidity and clonic contractions of the limbs that are very similar to the convulsions produced from faradic or citrate stimulation of the superior colliculus. It has been demonstrated by Magnus and others that removal of the cerebellum in a decerebrate rigid animal does not alter the tone This, however, does not necessarily mean that the cerebellum is not concerned with or may not alter muscle tone. In fact, Sherrington, Loewenthal and Horsley, Bremer, Miller and Banting have shown that weak faradic stimulation of the cortex of the vermis (palaeo-cerebellum) in decerebrate rigid animals inhibits this rigidity.

Concerning the two efferent pathways from the cerebellum to the formatio reticularis of the brain stem, the brachium conjunctivum and its main ascending division to the nucleus ruber and thalamus have generally been associated with muscle tone, but its descending division and its many endings in the formatio reticularis of the pons and medulla have apparently been entirely ignored in this connection. This important descending tract may be intact in many decerebrate rigid animals. The fastigiobulbar tract has received some consideration as a muscle tone pathway by Bernis and Spiegel and by Miller and Laughton. The former also called attention to the importance of fibers in the fastigiobulbar bundle that originate from the cortex of the vermis

To the writer the afferent connections to the formatio reticularis from the cerebrum, colliculi, corpora striata, and especially the diverse and extensive connections from the cerebellum suggest that considerable portions of the formatio reticularis function as efferent centers for tonic impulses. It may be that there are separate areas for inhibition as well as for augmentation. The usual explanation of the experiment of Magnus, where the decerebrate rigidity which resulted from transection of the brain stem below the nucleus ruber did not disappear with successive transecting of the medulla caudally until a level was reached directly below Deiter's nucleus, is that this section excluded all of Deiter's nucleus. On the other hand, it might be explained that the section below Deiter's nucleus eliminated all or practically all of the connections of the formatio reticularis of the brain stem.

The extensive distribution of the reticular formation through the brain stem and spinal cord may be used to good advantage in the "summation" and "recruitment" phenomena.

SUMMARY

Considerable evidence has accumulated in support of the formatio reticularis containing the chief visceral effective centers of the brain stem, which if true, would make the reticulospinal tracts the main pathways for effective visceral impulses in the spinal cord. There are also indications that this system may be associated with tonic impulses and clonic contractions. It is not the intention of the writer to minimize the importance of the hypothalamic nuclei as visceral motor centers, but rather to emphasize other equally important visceral effective areas in the formatio reticularis at lower levels.

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SCIENTIFIC NOTES AND NEWS

FREDERICK BATES, Chief of the Polarimetric Section of the Bureau of Standards, has recently returned from a tour of European laboratories. He was elected President of the International Commission for Uniform Methods of Sugar Analysis which was reconvened at Amsterdam, Holland, the week of September 5th, 1932 Approximately 50 delegates were present Practically all of the major countries interested in scientific development were represented A number of important international agreements on methods of scientific procedure were obtained and plans laid for much additional research through international cooperation

CURTIS P CLAUSEN of the Bureau of Entomology, formerly in charge of research work on parasites of the citrus black fly at Kuala Lumpur, Federated Malay States, has been transferred to Washington In his new assignment, he will coordinate the work of the Bureau and cooperating States on the study, breeding, importation, and distribution of beneficial insects

A. S. HITCHCOCK, custodian of grasses in the U S National Museum, has been elected a corresponding member of the Argentine Scientific Society.

GEORGE W LITTLEHALES, head of the division of research of the Hydrographic Office of the Navy, has been retired from active duty under the provisions of the economy bill after forty-seven years of service

HENRY S WASHINGTON, petrologist of the Geophysical Laboratory, Carnegie Institution of Washington, has been elected an honorary member of the Mineralogical Society, London

The 1932 directory of the Academy and affiliated societies has just come from the press Single copies may be purchased from the Treasurer, H G AVERS, Coast and Geodetic Survey, at a cost of 35 cents

Obituary

IRWIN G. PRIEST, chief of the colorimetry section of the Bureau of Standards, died suddenly on July 19, 1932. He was born near Loudonville, Ohio, on January 26, 1886 Graduating in 1907 from the Ohio State University, he came to the Bureau of Standards as a personal assistant to the director In 1913 he was made chief of the colorimetry section Much of the theory of interpreting spectrophotometric data in terms of dominant wave-lengths, purity, and brightness is due to him

Mr PRIEST was a fellow of the American Physical Society and the American Association for the Advancement of Science, a member of the Optical Society of America, the American Psychological Association, the Washington Academy of Sciences and the Philosophical Society of Washington He served as secretary (1921-24) and president (1928-29) of the Optical Society

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PALEOBOTANY.—*Megaspores ascribed to* Selaginellites, *from the Upper Cretaceous coals of Western Greenland.*[1] ERNEST LAVON MINER. (Communicated by H. H. BARTLETT.)

In this paper are described the most outstanding types of megaspores recovered from the samples of Upper Cretaceous Greenland coal, which were collected by Mr. Carl O. Erlanson in 1928. Dr C. A. Arnold (1) made a preliminary examination and a brief report on these coals, and suggested that a more detailed investigation be undertaken by the writer.

The specimens from which spores were obtained came from two localities, Patoot on the southeast coast of the Nugsuaks Peninsula at an elevation of 165 meters and Skansen on the east coast of Disko Island, two miles inland, at an altitude of 140 meters.

The coal beds of West Greenland range in age, without stratigraphic break, from Lower Cretaceous to Miocene. The coal layers are lenticular, varying in thickness from a few inches to several feet, and are interbedded between sandstone and shale (Ball 2; Bøggild 3, 4). The age of the coal from the localities under consideration appears to be Upper Cretaceous, since Heer (7, 8) recognized the Patoot series as having an Upper Cretaceous flora. White and Schuchert (12) give this series as extending up to about 2,000 feet above sea level. At Skansen, Seward (10), the most recent paleobotanist to study the fossil plant beds of Western Greenland, found Cretaceous strata at a height of 1,900 feet. The collections from Patoot and Skansen were at about 532 and 460 feet respectively, thus bringing these two localities well within the boundaries of the Upper Cretaceous.

[1] Papers from the Department of Botany of the University of Michigan, No 395. Received August 8, 1932.

Technique

The coal was macerated in bulk by soaking it in dilute nitric acid for a considerable length of time. After this treatment it was washed in water to remove the acid and then placed into a dilute sodium hydroxide solution until the maceration was complete. The resulting brown liquid was washed out and the residue examined under a binocular microscope.

The isolated plant fragments were treated for a short time in hot dilute nitric acid and potassium chlorate followed by hot dilute alkali. This second treatment with the hot acid and alkali helps to clear up and remove any debris adhering to the surface of the specimens. The material was transferred from water to 95% alcohol, and then mounted on a slide in "euparal." This method of mounting in "euparal" is similar to the formalin glycerine-jelly method mentioned by Harris (6) and is as follows:

1. Place the material in 95% alcohol for at least 30 minutes.
2. Transfer the specimens to the slide directly from 95% alcohol.
3. Draw off the 95% alcohol with filter paper or some other absorbent and add several drops of absolute alcohol. Let this stand for about a minute.
4. Draw off only enough absolute alcohol so that the specimens still remain moist and add enough "euparal" to form a thin coating over them.
5. Arrange the specimens on the slide.
6. Set the slide aside until the "euparal" sets sufficiently to hold the objects in place. This can be tested by running the point of a dissecting needle through the "euparal." If it has set, the needle will leave a white streak. The slide should be placed under cover to exclude particles of dust.
7. Add a drop or two more of "euparal" and place the cover glass.

This process makes a good permanent mount in which a large number of small plant fragments can be arranged systematically without having the specimens drift towards the edges of the coverslip as it is applied.

The Megaspores

The spores are very variable in size but each type defined shows no differences in structure. There appears to be a gradual increase in diameter from the smallest to the largest. Pfeiffer (9) shows that in the genus *Isoetes* the megaspores in general vary between 250 and 900 μ, with a much smaller range in the individual species. Variation

in some species amounts to as much as 310 μ, but the average variation for a species is around 100 μ or less. In the genus *Selaginella* there also occurs a great difference in the size of the megaspores within a species. Inequality in size of spores because of variation in megaspore number is shown by Duerden (5) to be common in certain species of *Selaginella*, and Van Eseltine (11) finds that very often one megaspore of the tetrad develops at the expense of the other three, which are then very much dwarfed. In a study of the megaspores of *Selaginella*, I also find a great variation of spore size within a species, the largest spores sometimes being twice as large as the smallest ones, with many intergradations.

In *Isoetes* and *Selaginella* the spores formed in tetrahedral groups usually have three commissural ridges (the "triradiate marks") on their inner face. These ridges extend from the apex of the inner face to an equatorial ridge which separates the inner and outer faces In *Selaginella* a raised equatorial ring is not always present or evident. When megaspores are formed from diads instead of tetrads the commissural ridges are absent. The surface of the spores may be either plain, rugose, spinose, tuberculate or reticulate wholly or in part. The sculpturing and appendages on the surface of the spores provide good diagnostic features.

Since the structures which bore the fossil spores are unknown it is impossible to determine accurately relationships to living plants, but since the markings and structures suggest a very close affinity to the *Selaginellaceae*, it seems very appropriate to place them in the form genus *Selaginellites*. *Selaginellites* was first instituted by Zeiller (13) for specimens from the coal basin of Blanzy, which appeared to differ from *Selaginella* in having more than four megaspores in each megasporangium Zeiller's distinction does not hold true when considered in the light of the work of Duerden (5) who finds the megaspore number per megasporangium ranging from one to 42 for some species of *Selaginella*. The name *Selaginellites* has been restricted to those species which are known to be heterosporous The genus *Lycopodites* of Brongniart is used in a more comprehensive sense to include all forms which are not known to be heterosporous, but it seems as though it should be restricted for those homosporous forms that show *Lycopodium* characters. *Selaginellites* as used here includes those fossil forms which have Selaginella-like characteristics, i e , are heterosporous.

The measurements given for the size of the spores should be interpreted as the range observed in a few clearly conspecific specimens and

not as the absolute limits, which can be established only by the examination of much more material.

Selaginellites erlansonii sp. nov.

Body of exine round, 465–1,000 μ in diameter, the mean being 690 μ; exine reticulate with irregular diaphanous appendages, 17–122 μ in width, giving the spore a total diameter of 500–1,155 μ with the mean at 790 μ; no commissural ridges or clefts visible.—Skansen, east coast of Disko Island, Greenland, two miles inland at altitude of 140 meters, Upper Cretaceous. Figures 1–3. This spore is seemingly quite abundant, but fragments of it are recovered more often than perfect specimens. The spores are dark brown or black and very opaque and this may help to account for the apparent lack of the triradiate markings. In Arnold's paper (1) this spore type is shown on Plate III, Figure 2. This species is named in honor of Mr. Carl O. Erlanson, the collector of the coal from which it was recovered, who was botanist on the second Greenland Expedition of the University of Michigan.

Selaginellites papillosus sp. nov.

Body of exine round, 648–747 μ in diameter, triradiate clefts extending about two thirds of the distance to the periphery, exine covered with numerous mamilliform papillae, hemispheric or higher than broad, with apex rounded.—Skansen, east coast of Disko Island, Greenland, two miles inland at altitude of 140 meters, Upper Cretaceous. Figure 9. This spore type was very rare.

Selaginellites arnoldii sp. nov.

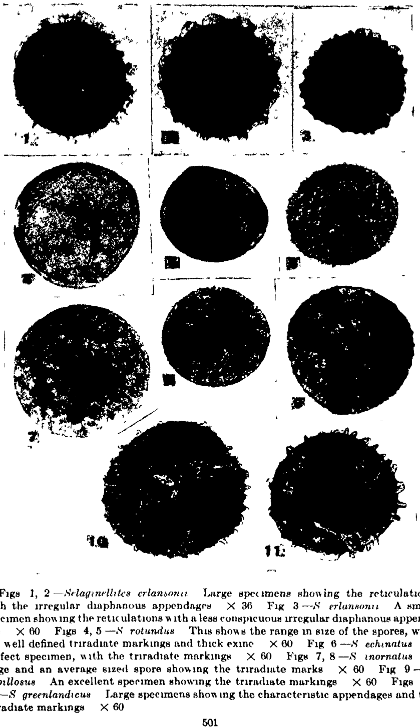
Body of exine round, 465–614 μ in diameter, average diameter 570 μ; triradiate marks extending over half the distance to periphery, body invested with numerous closely set vermiform papillae, 7–21 μ wide and 38–70 μ long, sides parallel, apex rounded.—Skansen, east coast of Disko Island, Greenland, two miles inland at altitude of 140 meters, Upper Cretaceous. Figures 22–25. Patoot, southeast coast of Nugsuaks Peninsula, Greenland, at 165 meters, Upper Cretaceous. This species was rather uncommon but not rare. It is figured by Arnold (1) on Plate IV, Figure 6. The spores are very interesting because of the peculiar appendages which invest the exine. The triradiate markings appear as fine lines.

Selaginellites greenlandicus sp. nov.

Body of exine round, 515–698 μ in diameter, the mean about 595 μ, triradiate clefts reaching half to two-thirds of the distance to the periphery, covered with finger-like appendages, 17–28 μ wide and 17–44 μ long, with sides nearly parallel, and apex rounded or blunt, usually somewhat distantly set.—Skansen, east coast of Disko Island, Greenland, two miles inland at altitude of 140 meters, Upper Cretaceous. Figures 10, 11. This spore was about equal in abundance to *S. arnoldii*.

Selaginellites echinatus sp. nov.

Body of exine round, 349–400 μ in diameter; triradiate clefts extending about two thirds of the distance to the periphery, exine covered with echinate appendages, tapering to an acute point, straight or somewhat curved.—Skansen, east coast of Disko Island, Greenland, two miles inland at altitude of 140 meters; Upper Cretaceous. Figure 6. This form was as rare in the coal as *S. papillosus*.



Figs 1, 2 —*Selaginellites erlansonii* Large specimens showing the reticulations with the irregular diaphanous appendages × 36 Fig 3 —*S erlansonii* A small specimen showing the reticulations with a less conspicuous irregular diaphanous appendage × 60 Figs 4, 5 —*S rotundus* This shows the range in size of the spores, with the well defined triradiate markings and thick exine × 60 Fig 6 —*S echinatus* A perfect specimen, with the triradiate markings × 60 Figs 7, 8 —*S inornatus* A large and an average sized spore showing the triradiate marks × 60 Fig 9 —*S papillosus* An excellent specimen showing the triradiate markings × 60 Figs 10, 11 —*S greenlandicus* Large specimens showing the characteristic appendages and the triradiate markings × 60

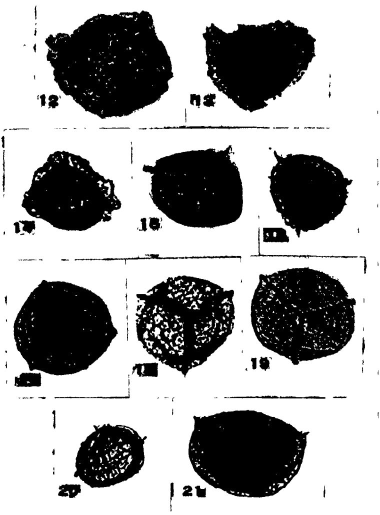
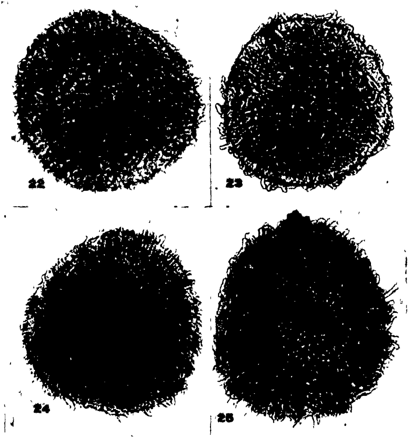


Fig 12 - *Selaginellites borealis* A small spore in a very wrinkled condition, but showing the triradiate markings and a portion of the equatorial wing × 96 Figs 13, 14 —*S borealis* Excellent specimens showing the spore body and the almost complete equatorial wing × 66 Fig 15 —*S borealis* A somewhat wrinkled specimen showing the extent of the triradiate marks and a portion of the wing × 66 Fig 16—*S borealis* A specimen with the wing missing, but showing the triradiate marks extending beyond the periphery of the spore body × 66 Figs 17, 18 —*S borealis* Specimens showing only a small portion of the equatorial wing on the radii of the triradiate marks × 66 Fig 19 - *S borealis* A specimen consisting of only the inner face of a spore, showing the triradiate markings and the inconspicuous reticulations × 66 Fig 20 —*S borealis* A somewhat wrinkled specimen, from which the equatorial wing has been broken, showing only the spore body × 66 Fig 21 - *S borealis* A specimen somewhat flattened laterally showing the triradiate markings extending a little beyond the periphery of the spore × 66

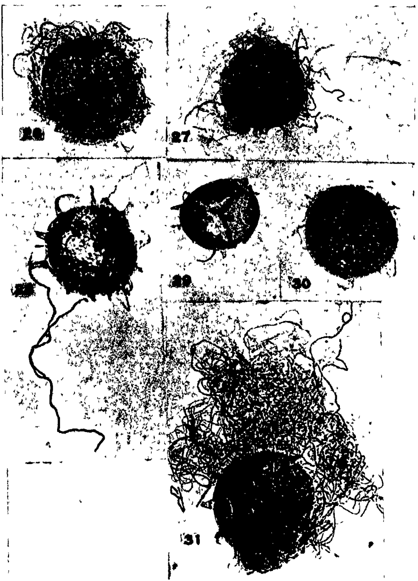
Selaginellites borealis sp. nov

Body of exine practically round, 265–350 μ in diameter, equatorial wing 50–83 μ wide on the radii of the triradiate markings, and 16–50 μ in between, making the total diameter of the spore 332–480 μ, triradiate markings extending to the periphery of the wing, irregular reticulations present but not conspicuous.—Skansen, east coast of Disko Island, Greenland, two miles



FIGS 22–25.—*Selaginellites arnoldii* Excellent specimens showing the peculiar vermiform papillae which cover the spore The triradiate marks show as fine black lines in Figs 22, 23 × 110

inland at altitude of 110 meters, Upper Cretaceous Figures 13–21. Patoot, south coast of the Nugsuaks Peninsula, at altitude of 165 meters, Greenland, Upper Cretaceous Figure 12 This spore type is figured by Arnold (1) on Plate IV, Figure 1 It was more abundant in the coal from Skansen, than in that from Patoot The exine of this species seems to be quite thin and delicate as in many instances the spores are very wrinkled and the wing is broken or missing



Figs 26, 27, 31—*Selaginellites ariadnae* Specimens showing the tangled and matted condition of the thread-like appendages × 97 Fig 28—*S ariadnae*. A spore from which part of the appendages were removed so as to show the long thin appendages, with the broader funnel-form base × 97 Fig 29—*S ariadnae* A specimen from which the appendages and a portion of the wall were removed so as to show the triradiate clefts × 97. Fig 30—*S ariadnae* A view of the outer face of a spore showing the distribution, arrangement, and attachment of the appendages × 97.

Selaginellites inornatus sp nov

Body of exine round, 200–664 μ in diameter, the mean being 440 μ, exine smooth, 5–18 μ thick, triradiate clefts extending a third to a half of the distance to the periphery, clefts slightly margined —Skansen, east coast of Disko Island, Greenland, two miles inland at altitude of 140 meters; Upper Cretaceous. Figures 7, 8 This spore was the next most abundant *Selaginellites,* but was found generally in a broken or damaged condition

Selaginellites subrotundus sp. nov.

Body of exine rounded-subdeltoid, 432–698 μ in diameter, the average being near 506 μ, exine 30–40 μ thick, triradiate clefts with somewhat thickened margins, extending two thirds or more of the distance to the periphery, exine smooth —Skansen, east coast of Disko Island, Greenland, two miles inland at altitude of 140 meters, Upper Cretaceous Figures 4, 5. Although not as abundant as *S inornatus* this spore was generally recovered in excellent condition This may be because of its very thick exine. It resembles the former species very much, but differs in the thicker exine, larger size, and more deltoid shape.

Selaginellites ariadnae sp nov.

Body of exine round, 150–316 μ in diameter, the mean being 233 μ, triradiate clefts extending over half the distance to the periphery, body invested with 8–15 thread-like appendages, 3–4 μ in width, few to several times the diameter of the spore in length, base broad and funnel-form, apex blunt or rounded —Skansen, east coast of Disko Island, Greenland, two miles inland at altitude of 140 meters, Upper Cretaceous Figures 26–31 This is the predominating spore type recovered from the coal It is usually entangled by the thread-like appendages, which sometimes completely hide the spore. It is only after untangling and straightening out the appendages that the real structure of the spore can be seen The number of visible appendages depends upon the plane in which the spore was flattened, the fewest number being on the inner face of the spore

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PALEONTOLOGY —*Antillophyllia, a new coral generic name.*[1] THOMAS WAYLAND VAUGHAN, Scripps Institution of Oceanography.

The genus *Antillophyllia* may be defined as follows

Corallum simple, turbinate, compressed turbinate, bilobate, or sub-cornute in form, attached at least in the earliest stages, pedicel minute or moderately large Externally invested by a more or less complete, detachable epitheca Costae distinct, moderately prominent, subequal or equal in size, margins with very regular, usually transversely compressed dentations Septa numerous, with minutely dentate margins, the dentations frequently (if not always) papilliform in character Margins of the larger septa divided by a sinus into an inner and outer lobe, the inner very narrow in the constricted portion of bilobate calices Septal faces with fine opposed striations, along whose courses are granulations The striations are finer on the inner than on the outer septal lobe Columella not greatly developed, compressed in the plane of the greater diameter of the calice, vesicular Dissepimental endotheca very abundant, exotheca frequently well developed, sometimes forming a wall outside of an inner wall which originates by the thickening of the sides of the septa

Type species —*Antillia lonsdaleia* Duncan from the Miocene of the Dominican Republic

P Martin Duncan (1864, p 28) proposed the name *Antillia* and included in it four species, viz , *Montlivaltia ponderosa* Duncan (not Milne Edwards and Haime), *Antillia dentata* Duncan, *A lonsdaleia* Duncan, and *A bilobata* Duncan. He later added another species, *A. walli* (Duncan and Wall, 1865, p 11) These five species represent two systematic groups of corals, one of which has coarsely dentate septal margins, contains the species wrongly identified as *Montlivaultia ponderosa* M. Edw and Haime and *Antillia dentata* Duncan It is related to the mussoid corals. The other group has septa with finely dentate margins and to it belong *A. lonsdaleia*, *A. bilobata*, and *A. walli*, all described by Duncan.

There was confusion at the start Not only did Duncan include two different genera under *Antillia* when he first proposed the name, but he made a double misidentification of species. Comparison of photographs of the type of *Montlivaultia ponderosa* M Edwards and Haime kindly sent me from the Museum of Natural History in

[1] Received August 16, 1932

Paris shows that Duncan's *Montlivaltia ponderosa* from the Miocene of Bowden, Jamaica, is not *Montlivaultia ponderosa* Milne Edwards and Haime. I undertook to correct this error by naming the Bowden, Jamaica, species *Antillia gregorii* (Vaughan, 1901, p. 6) The specimens from the "Nivajé Shale," Dominican Republic, identified by Duncan as "*Antillia ponderosa*" is, as shown by an examination of the specimen studied by Duncan, not the same species as the Bowden "*Antillia ponderosa,*" but is Duncan's *Antillia dentata* from the Dominican Republic. Duncan's *Antillia ponderosa*, therefore, included two species, neither one of which was *Montlivaultia ponderosa* M. Edwards and Haime

J W. Gregory (1895, p. 266) wrote as follows

> "The inclusion in the list of synonyms of a species which Duncan assigned to *Antillia* renders necessary a remark on this genus, and on the value of the epitheca in this group The genus was founded by Duncan in 1864, he included in it a series of species agreeing in having an essential columella and a membraniform epitheca The septa and costae are of two types in some species, as in his type-species *A ponderosa*, the septa are not lobed and the costae are coarsely dentate, in other species, such as *A lonsdaleia*, the septa are lobed and the costae finely granulate In his 'Revision' (p 60) he reduces the genus to a subgenus of *Circophyllia*, and still bases its value on the epitheca
>
> The examination of a considerable series of specimens shows, however, that the epitheca is so very variable in this group that it does not appear worthy of even subgeneric value, the characters of the septa and costae seem much more important In some specimens the epitheca is present and in others, quite rudimentary, and all stages can be seen between the two conditions In this case the genus has to be split up into two Duncan's type goes into *Lithophyllia*, and the *A lonsdaleia* and some others go into *Circophyllia* "

In 1901 I wrote (Vaughan, 1901, p. 6)

> "I am not sure that these two species (*Lithophyllia lacera* (Pallas) and *L cubensis* (M Edw & H) are really distinct, however, I am sure that *Antillia ponderosa* Duncan (*non*-Milne Edwards and Haime) is a distinct species and does not belong in the synonymy of *L cubensis* As Duncan wrongly identified the species with Milne Edwards and Haime's *Montlivaultia ponderosa*, it has no name Therefore I propose to call it *Antillia gregorii*, nom nov."

The type species of *Antillia* is *Antillia gregorii* Vaughan, which is, as has been stated, Duncan's *Antillia ponderosa*, not *Montlivaultia ponderosa* Milne Edwards and Haime.

Reuss (1860, p. 216, pl 1, figs. 10–12, pl 2, fig 10) described the genus *Syzygophyllia* from the eastern Hungarian Miocene The type species is *S. brevis* Reuss (Vaughan, 1919, p 424). *Antillia* Duncan, 1864, is a synonym of *Syzygophyllia* Reuss, 1860.

A few notes will be made on *Circophyllia*. Filliozat (1914, pp. 96-97) has said:

"Grace à la grande complaisance de M le Professeur Joubin, j'ai eu depuis l'occasion d'examiner attentivement au Muséum les échantillons de *Circophyllia truncata* de la collection Milne Edwards. Je puis alors constater que la diagnose des auteurs présentait des lacunes de la plus haute importance et que mes spécimens de la ferme des Boves, à Parnes, décrits sous le nom de *Felixopsammia arcuata* [Filliozat, 1910, p 804, pl. 14, figs 7-11] devaient etre identifiés à *Circophyllia truncata* E H."

From Filliozat's restudy of the type-species of *Circophyllia*, it is evident that none of the corals placed in *Antillia* by Duncan can be referred to *Circophyllia*, which is an Eupsammid genus. Duncan's *Antillia lonsdaleia*, *A. bilobata*, and *A. walli* are, therefore, without a proper generic designation.

I must now confess my own sins. Notwithstanding that it was known to me that the name *Antillia* was invalid, I applied it to species of corals as follows *Antillia dubia* (Duncan) and *A. bilobata* Duncan (Vaughan, 1921, p. 115), *A. bilobata* Duncan (*idem*, p. 127), *A. dominicensis* Vaughan (*idem*, p. 152), *A. bilobata* Duncan and *A. walli* Duncan (*idem*, p. 157), *Antillia dominicensis* Vaughan (Vaughan and Hoffmeister, 1925, p. 324, pl. 3, fig. 9, pl. 4, figs 1, 2, which are upside down), and *A. sawkinsi* Vaughan (Vaughan and Hoffmeister, 1926, p. 118, pl. 2, figs. 6, 6a).

I should accept responsibility for the misuse of the name by Hoffmeister (Vaughan and Hoffmeister, 1926, p. 119, pl. 2, figs. 7, 7a, 8, 8a) in his *Antillia bullbrooki* and by Faustino (1927, p. 152, pl. 37, figs. 2, 3) in his designation of *Antillia constricta* Brueg. *A. constricta* does not belong to the mussoid corals.

It is also probable that I misled Yabe and Sugiyama in their use of the name *Antillia*.

I shall not undertake a complete revision of the species that have been confused under *Antillia*, but I shall list the American species, the generic identification of which seems certain, and comments will be made on a few other species.

The species which belong to *Antillia* as represented by the type-species, but which are now referred to *Syzygophyllia*, because that is the older name, are as follows.

Syzygophyllia gregorii (Vaughan)
dentata (Duncan)
hayesi (Vaughan)

The American Miocene species which have been referred to *Antillia* and which are now placed in the genus *Antillophyllia* are as follows:

Antillophyllia lonsdaleia (Duncan) genotype
bilobata (Duncan)
walli (Duncan)
dubia (Duncan) (described as Flabellum)
dominicensis (Vaughan)
sawkinsi (Vaughan)
bullbrooki (Hoffmeister)
ponderosa (M. Edw. and H.)

I am in doubt regarding *Antillia explanata* Pourtalès, a Recent Barbadian species.

A few Indo-Pacific living species which obviously belong to *Antillophyllia* are *A. geoffroyi* (Audouin), *A constricta* (Brueg.), *A. sinuata* (Gardiner), and *A. flabelliformis* (Yabe and Sugiyama).

Yabe and Sugiyama (1931) repeated Duncan's error in their treatment of *Antillia*, but I have already stated that I may be at least partly to blame for their confusion. *A constricta* Brueg. and *A flabelliformis* Yabe and Sugiyama clearly belong to *Antillophyllia*, and *A. duncani* Yabe and Sugiyama probably does But *Antillia japonica* Yabe and Sugiyama and *A. nomaensis* Yabe and Sugiyama are mussoid corals and do not belong to the same genus as the other species The last mentioned two species do not appear to be referable to *Syzygophyllia* but look as if they probably represent the young stages of one or more species of mussoid corals which are compound in the adult stages.

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PALEONTOLOGY.—*A new species of* Lepidocyclina *from the Panama Canal Zone.*[1]

THOMAS WAYLAND VAUGHAN, Scripps Institution of Oceanography, and W. STORRS COLE, Ohio State University.

The species described below was picked out of material collected by Prof. R. W Chaney for the senior author in the Panama Canal Zone, at a locality formerly known as Bohio Ridge Switch. The locality is the same as no. 6025 of the Vaughan and MacDonald collections made in 1911 (See MacDonald, 1919, p. 540, and pl. 154).

Lepidocyclina (Lepidocyclina) pancanalis Vaughan and Cole, n. sp.

Figs 1-9.

Test small, lenticular, relatively inflated, slope from central area to margin nearly uniform, without or with a very narrow marginal flange Outline in plan subcircular or faintly polygonal One vaguely hexagonal specimen has obscure radii at the edge (Fig 6) The ornamentation is of two intergrading kinds On some specimens there are over the center of the test small papillae which are about 130 μ in diameter, as shown on Figures 1–4, 6 On other specimens the papillae are larger and tend to fuse The latter kind of ornamentation grades into costulation of the apex, such as is represented by Figure 5 Although four flattish costae, with intervening depressed areas, are shown on the apex of this specimen, the costulation is indefinite A specimen not figured has an apical, central, coarse papilla, with smaller papillae and faint costules around it Over the centers of some specimens, Figs. 1 and 2, there are slight depressions It seems that no two specimens are exactly alike The foregoing notes are based on seven specimens, six of which are figured

The diameter of megalospheric specimens ranges from 1 5 to 2.0 mm and the thickness through the center ranges from 0 75 to 1 0 mm Ratio of diameter to thickness, about two to one

There are two subequal, small, embryonic chambers which are divided by a straight wall The length of the two chambers is about 185 μ, width, about 145 μ, thickness of wall, about 25 μ.

The equatorial chambers are of three intergrading kinds Most of the chambers have curved outer and converging inner walls, some of them are

[1] Received August 16, 1932.

diamond shaped; those nearest the periphery are nearly hexagonal or of short spatulate form. The chambers near the center have a transverse diameter of 35 to 45 μ and a radial diameter of 30 to 40 μ, those near the periphery have a transverse diameter of about 50 μ and a radial diameter of about 60 μ Near the center the height is about 30 μ The height increases very gradually toward the periphery where it is about 55 μ The chambers are connected by stolons, the openings for which are about 7 μ in diameter They are shown in the vertical illustrated by Figure 8

The lateral chambers form regular tiers There are about 10 in a tier on each side of the equatorial layer over the center Outward, the number in a tier regularly decreases toward the periphery where there is only one layer on each side of the equatorial layer. Just over the embryonic apparatus the height is about 20 μ and the length about 40 μ There is increase in size outward until at the periphery over the central area the height is about 40 μ and the length about 60 μ A few relatively strong pillars are developed between the tiers over the center of the test

The species to which *L pancanalis* is most nearly related is *L canellei* Lemoine and R Douvillé *L canellei* is usually larger, but the senior author has specimens of a dwarf variety from Arbol Grande, near Tampico, Mexico In *L canellei* the ratio of the diameter to thickness is greater, and in perfectly preserved specimens there is a distinct flange which may be peripherally thickened *L canellei* lacks the pillars and the thickened surface papillae and costulations of *L pancanalis* The equatorial chambers of *L. canellei* are strikingly regular hexagonal in shape, while those of *L pancanalis* are dominantly of diamond or short-spatulate form

Co-types and topo-types The specimens on which the foregoing description is based and which are here illustrated, have been donated to the U S National Museum Topotypes, Scripps Institution of Oceanography

Geologic relations and associated species The locality at which the type-specimens were collected has already been stated The geologic horizon is given by MacDonald as the upper part of the Culebra formation, but actually the stratigraphic relations of the bed from which the specimens were collected is not certainly known The senior author surmises that the bed does not belong within, but lies below the Culebra formation

Associated with *L pancanalis* at its type locality are other organisms as follows (see Vaughan, 1919*b*, pp 550–554, 1924, pp. 787, 802)

Camerina panamensis (Cushman)

Heterostegina n. sp (described in a ms by D W Gravell)

Miogypsina (*Miolepidocyclina*) *panamensis* (Cushman)

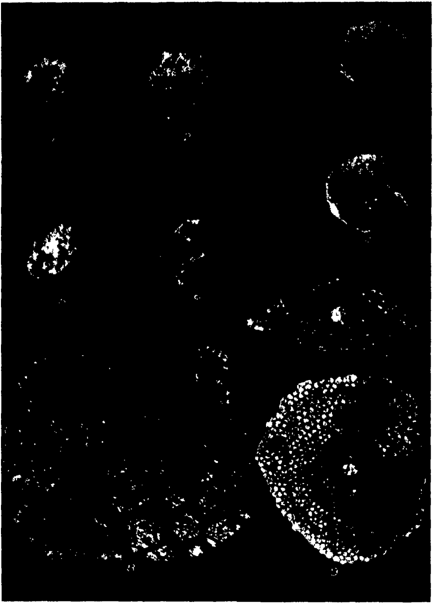
Lepidocyclina sp , erroneously identified by Cushman as *L chaperi*

In Antigua, *L pancanalis* has been found in collections made by W R Forrest at Cocoanut Hall, in the upper stratified beds at Half Moon Bay, and at southeast point, Long Island Commonly, associated with *L pancanalis* at these localities are

Lepidocyclina parvula Cushman

undosa Cushman

vaughani Cushman



Lepidocyclina (Lepidocyclina) pancanalis Vaughan and Cole, n sp

Figs 1–6 —Surface views, × 12, of six specimens

Fig 7 —Vertical section, × 28.

Fig 8.—A part of a vertical section, × 200, to show the stoloniferous apertures in the walls of the equatorial chambers. Three pairs of the apertures are represented by the pairs of white dots

Fig 9.—Equatorial section, × 28, to show the embryonic and equatorial chambers.

The horizon in Antigua is in the Antigua formation, but it may be considerably above the base of the formation

Collateral information on the probable correlation of the Panama exposure above discussed may be obtained by comparing it with the exposure at locality 6024 of MacDonald's report (1919, p 540). The two are very near together At this locality the following species were collected·

In the lower 10 ft.	*Camerina panamensis* (Cushman)
	Miogypsina (*Miolepidocyclina*) *panamensis* (Cushman)
In the upper 10 ft	*Stylophora imperatoris* Vaughan[2]
	macdonaldi Vaughan[2]
	Acropora panamensis Vaughan[3]
	saludensis Vaughan[3]

There are two other groups of facts that bear on the stratigraphic position of the exposure at locality 6025 The first of them is that at MacDonald's locality 6026 (1929, p. 541) there is an Antiguan middle Oligocene coral fauna. A species of *Camerina* was doubtfully identified as *C panamensis* In the Panama Canal Zone *L canellei* and *L vaughani* occur in association (Vaughan, 1923, pp. 254, 255), but in Antigua, *L. vaughani* occurs in association with *L pancanalis*. Specimens previously reported by the senior author as *L. canellei* from Half Moon Bay, have proved in detailed study to be *L pancanalis*. The second group of facts is that *Miogypsina cushmani* occurs in the vicinity of Culebra in both the upper part of the Culebra formation and in the immediately overlying Emperador limestone.

Notwithstanding lack of the desired definiteness in the information given above, the indications are that the stratigraphic position of the bed exposed at locality 6025 is about the same as the beds exposed at Half Moon Bay, Antigua, but below the horizon of *Miogypsina cushmani* in the upper part of the Culebra formation as that formation was exposed in Gaillard Cut before water was let into the Panama Canal. As the beds at Half Moon Bay occur within the Antigua formation, but apparently not in its basal part, the stratigraphic position of the bed exposed at locality 6025 in Panama is Oligocene, perhaps upper rather than middle The European age equivalent is probably Chattian

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[2] Also in the Emperador limestone which overlies the Culebra formation

[3] Also in the middle Oligocene, Antigua formation at Rifle Butts, Antigua (see Vaughan, 1919*a*, pp 201, 208, 209).

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ENTOMOLOGY --*A new species of* Rhodnius *from Panama (Hemiptera Reduviidae)* [1] H. G BARBER, Bureau of Entomology. (Communicated by HAROLD MORRISON)

Rhodnius pallescens n sp

Color Pale testaceous, dull, marked with fuscous Head beneath and laterally, before the eyes, and a narrow longitudinal stripe behind the eyes on a line with the ocelli, fuscous, a conspicuous, narrow, median, longitudinal, pale testaceous line running from extreme apex to base of head, somewhat widened between the eyes Antennae with the first segment, a little over basal half of second, and most of the fourth, except at extreme base and apex, pale testaceous, often faintly mottled with fuscous, the remainder infuscated Rostrum sordid testaceous, faintly mottled with brown Pronotum conspicuously marked with pale testaceous on a fuscous background, lateral margins and two longitudinal carinae, one on either side of the middle, very plainly calloused, pale testaceous, the anterior lobe between the two median carinae with two elongate, oval, unbroken fuscous spots, anteriorly narrowed and not attaining the depressed anterior margin, just within the anterior angles a small, subtriangular, fuscous spot, behind which is a broken fascia, of the same color, occupying the space on each side between the lateral margin and the median carina, posterior lobe granulose, with many pale testaceous pustules on a fuscous background, a median, longitudinal, testaceous, slightly calloused, granulated stripe between the two median carinae, and a broader, more irregular, non-calloused fascia on each side between the lateral margin and the median carina Scutellum pale testaceous, disk with three distinctly excavated fuscous spots basally, the median one frequently immaculate, the inclined sides infuscated to beyond the middle. Hemielytra with the surface for the most part pale testaceous, with the veins concolorous, median or inner field of the corium with a conspicuous, broad, slightly curved, fuscous stripe, a much narrower and less conspicuous stripe contiguous to and paralleling the submedian nervure, sometimes also the claval suture anteriorly, and extreme apex of corium, infuscated The membrane pale, sordid testaceous, with the outer long cell, except along the limiting veins, faintly embrowned, with pale irrorations through the center, the inner long cell very slightly embrowned before the middle, the surface posterior to the long cells frequently irrorated or tinted with brown The connexivum pale testaceous, each segment anteriorly at the lateral margin with an elongate, rectangular fascia, over twice as wide as long and narrowly separated from a more elongate narrower stripe, partially concealed by the margin of the corium Pleura fuscous, granulose, broadly and irregularly striped, and mottled with testaceous Venter embrowned, with two or three longitudinal series of irregular

[1] Received August 15, 1932

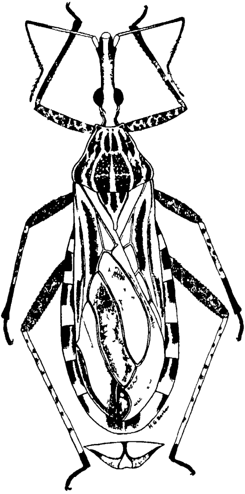

Fig 1 —*Rhodnius pallescens* n sp

pale testaceous spots on either side toward the lateral margins Legs pale testaceous, mottled with brown, the tibiae apically and the tarsi embrowned. Head laterally finely and densely granulose, 4 64 mm long and 1.6 mm. wide across the eyes, space between the eyes slightly longer than the diameter of an eye (0 56 mm. to 0 52 mm.), distance from eye to apex of antenniferous tubercle (lateral view) 2¾ to 2½ times as long as from the apex of the latter to the front of the clypeus, antennae as long as head and pronotum together, basal segment attaining the apex of the lateral lobes, second segment about seven times as long as first, the relative lengths of the segments as follows· I 0 48, II 3 20, III 2 40, and IV 1 60 mm , third and fourth segments sparsely pilose Rostrum reaching very nearly to margin of anterior acetabulae; first and third segments equal to each other, the second segment 4 to 4½ times as long as either of the other two Pronotum distinctly wider than long (4 mm to 3 04 mm), anterior lobe, on the median dorsal line, 1 04 mm long, the posterior lobe 2 mm long, lateral margins distinctly concavely sinuate between the lobes, anterior angles prominent, forming somewhat rounded lobes anteriorly, lateral margins and two median longitudinal carinae strongly calloused, dorsal surface of posterior lobe elsewhere covered with conspicuous small, pale, testaceous pustules. Scutellum longer than wide (2 mm to 1.76 mm), disk with three strongly excavated longitudinal areas basally, the median one attaining the middle of the scutellum, contracted apical part transversely furrowed, cylindrical, somewhat elevated Hemielytra not quite reaching apex of abdomen, entire length from base of corium to apex of membrane 12 mm , corium along costal margin 8 mm long; length of inner cell of membrane 5 6 mm , of outer cell 6 mm Length of body from posterior margin of pronotum to apex of abdomen 12 16 mm Connexivum broadly exposed; diameter of abdomen at third segment 5.6 mm. Pleura granulose, pustulate.

Length of male 19.84 mm , diameter of pronotum 4 mm , diameter of abdomen 5 6 mm ; length of female, 21–32 mm

Type male La Chorrera, Panama, V, 12, 1912 (collected by August Busck) Paratypes, males four with same data as type, one Trinidad River, Panama, V, 8, 1911 (August Busck), females one La Chorrera, Panama, V, 10, 1912, one Cabima, Panama, V, 28, 1911 (August Busck), one Close's, Cano Saddle, Canal Zone, Panama, IX, 1923 (M F Close), and two Ancon, Canal Zone, Panama, VII, 1932 (L H Dunn, Gorgas Memorial Laboratory) U S N M Cat No 44329

There is very little variation in the series of eleven specimens at hand from Panama *Rhodnius pallescens* is closely related to both *prolixus* Stål and *pictipes* Stål, from either of which it differs especially in its paler coloration and relative proportion of parts, having a longer and narrower head and pronotum.

The lower part of Figure 1 shows the posterior view of the genitalia.

Key to Three Species of Rhodnius

1 First, second, and base of third segment of antenna and legs uniformly pale chestnut-brown, not mottled or banded with fuscous Disk of scutellum with a single basal excavation. Dimensions of parts of male as follows· head 4 16 mm long, 1.74 mm wide across eyes, apex of head to eyes 2 4 mm , dorsal diameter of eye 0 56 mm., vertex between eyes 0 62 mm , second segment of rostrum 3½ times

as long as basal; pronotum 2.96 mm long, 4 mm wide, anterior lobe 1.04 mm and posterior lobe 1.92 mm. long, scutellum 1.68 mm. long, 1.6 mm. wide; length of body from posterior margin of pronotum to apex of abdomen 11.04 mm., diameter at third segment 5.2 mm **prolixius** Stål.

First two segments of the antenna not unicolorous, legs mottled with brown and the tibiae sometimes banded with fuscous. Disk of the scutellum with three excavations ... 2

2. Antenna with basal segment, apical part of second, and base of third and fourth segments infuscated, tibiae with two fuscous bands, one median and one apical. Fuscous spots on segments of connexivum posteriorly forked. Dimensions of parts of male as follows: head 4.56 mm long, 1.68 mm. wide across eyes, apex of head to eyes 2.54 mm., dorsal diameter of eye 0.6 mm., vertex between eyes 0.48 mm., pronotum 3.36 mm long, 4.16 mm wide, anterior lobe 1.2 mm., posterior lobe 2.16 mm long, scutellum 2.08 mm long, 1.8 mm wide, length of body from posterior margin of pronotum to apex of abdomen 11.28 mm., diameter at third segment 5.44 mm. **pictipes** Stål

Antenna with apex of second, all of third, and sometimes narrow base and apex of fourth segment infuscated. Legs pale testaceous, mottled with brown, tibiae without a median fuscous band but infuscated at apices. Elongate rectangular spots on segments of connexivum not posteriorly forked. Dimensions of parts of male as follows: head 4.64 mm long, 1.6 mm wide across eyes, apex of head to eyes 2.8 mm., dorsal diameter of eye 0.52 mm., vertex between eyes 0.56 mm., pronotum 3.04 mm long, 4 mm wide, anterior lobe 1.04 mm., posterior lobe 2 mm long, scutellum 2 mm long, 1.76 mm wide, length of body from posterior margin of pronotum to apex of abdomen 12.16 mm., diameter at third segment 5.6 mm **pallescens** n. sp.

ZOOLOGY.—*Annotations on the nomenclature of some plant parasitic nematodes.*[1] G. STEINER, Bureau of Plant Industry.

In a recent paper (Steiner 1931) attention was called to the fact that the genus *Aphelenchus*, as previously conceived, contained through error, some species not possibly belonging to it. The proposition was therein made to raise to generic rank the group for which Cobb, 1927, had created the subgeneric term, *Pathoaphelenchus*.

In 1894, however, Fischer described under the name of *Aphelenchoides kuhnii* (Fischer speaks of a subgenus but later in his paper places "nov. gen. et nov. spec." after the name) a form which in our judgment is *Aphelenchus parietinus* of Bastian, 1865, and which in turn is the type of *Pathoaphelenchus*. *Aphelenchoides* Fischer 1894, antedates *Pathoaphelenchus* Cobb 1927, and therefore replaces it, with *Aphelenchoides parietinus* (Bastian) Fischer 1894 as type. Synonyms of this type species are *Aphelenchus modestus* de Man 1876, *Tylenchus gracilis* Cobb 1888 (=*Aphelenchus gracilis* Cobb 1891, =

[1] Received July 19, 1932

Tylenchus cobbi de Man 1906), *Aphelenchus ormerodis* Ritzema Bos 1891, and *Aphelenchoides kuhnii* Fischer 1894

It may further be noted that *Tylenchus gulosus* Kühn 1889 and Fischer 1894, is a synonym of *Tylenchus pratensis* de Man 1884 This adds the following plants to the list of hosts of *T. pratensis* *Beta vulgaris* var *rapa*, *Brassica campestris*, *Linum usitatissimum*, *Pisum sativum*, *Vicia villosa*, *Clematis jackmani*, and *Hepatica triloba*

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1030TH MEETING

The 1030th meeting was held in the Cosmos Club Auditorium, Saturday evening, December 19, 1931 The meeting was called to order at 8 15 P M by President TUCKERMAN

Program: E. O. HULBURT: *The temperature of the lower atmosphere.*—From the known amounts of the various gases of the atmosphere from sea-level to about 20 km, from the observed light-absorption coefficients of the gases and from the albedo of the Earth's surface, the temperature of the atmosphere in radiative equilibrium is calculated on the assumption that the sunlight is the only source of energy. The sea-level temperature comes out to be about 19° above the observed world-wide average value 287°K, and the temperature above about 3 km falls many degrees below the observed temperatures. The temperature gradient in levels from 3 to 6 km is greater than that of convective equilibrium and hence the atmosphere would not be dynamically stable if radiation equilibrium prevailed. Therefore air-currents take place to bring about convective equilibrium. Continuing the calculation it is found that only when the convective region extends to about 12 km (as is observed), with radiative equilibrium above 12 km (as is observed), does the atmosphere satisfy the conditions of dynamic stability and thermal equilibrium with the received solar energy. For this case the calculated sea-level temperature is 290°K in good agreement with the observed value 287° K.

Calculation shows that doubling or tripling the amount of the carbon dioxide of the atmosphere increases the average sea-level temperature by about 4° and 7° K respectively, halving or reducing to zero the carbon dioxide decreases the temperature by similar amounts. Such changes in temperature are about the same as those which occur when the Earth passes from an ice age to a warm age, or *vice versa*. Thus the calculation indicates that the carbon-dioxide theory of the ice ages, originally proposed by Tyndall [Phil. Mag., **22,** 277 (1861)], is a possible theory. (*Author's abstract.*)

Discussed by Messrs. WHITE, L. H. ADAMS, HUMPHREYS, CURTIS, and HAWKESWORTH.

O. R. WULF: *The ozone distribution and the temperature of the upper atmosphere.*—Experimental evidence and theory combine to indicate that the ozone of the upper atmosphere is distributed as a fairly sharply defined layer, and that this is located at a height of roughly 50 kilometers. In work done recently at the Fixed Nitrogen Research Laboratory by Dr. E. H. Melvin and the author an influence of temperature has been found in the ultraviolet absorption bands of ozone. In view of the above, a method is proposed for the direct determination of the temperature of the upper atmosphere at the height of the ozone layer. This comprises a photometric comparison of the atmospheric ultraviolet ozone absorption in the spectra of stars giving a satisfactory continuous background in this region, with the same ozone absorption spectra taken at a series of temperatures in the laboratory. (*Author's abstract.*)

Discussed by Messrs. HULBERT and HUMPHREYS.

An informal communication was presented by A. H. SCOTT on *Dielectric constant and power factor of fused zinc oxide.*

1031ST MEETING

The 1031st meeting was held in the Cosmos Club Auditorium, Saturday evening, January 16, 1932. It was called to order at 8.30 P.M. by President TUCKERMAN.

Program: H. L. CURTIS: *The determination of the electrical units by mechanical measurements.* This paper has been printed in full in the pages of this JOURNAL (**22:** 193).

1032D MEETING

The 1032nd meeting was held in the Cosmos Club Auditorium, Saturday evening, January 30, 1932. The meeting was called to order at 8 15 P.M. by President TUCKERMAN

Program· F. L. MOHLER. *Temperature variations of the absorption of metallic silver.*—Published work has shown that the sharp transmission band of silver with its maximum at 3200 AU changes with temperature. A quantitative study of this has been made by the method of photographic densitometry over the temperature range 220°C to −253°C (boiling hydrogen). The quantity measured is

$$\log J_o - \log J = a$$

where J_o is the incident intensity and J the transmitted intensity and values are given in common logarithms. For films of chemically deposited silver and of silver evaporated in vacuum and for films of different thickness, the change in a between fixed temperatures remains proportional to a The change is limited to the wave-length range 3400 AU to 2900 AU with the maximum effect near 3100 AU The short wave-length branch of the absorption curve becomes less steep with increasing temperature and the minimum less pronounced while the long wave-length branch is unchanged For one specimen the value of a at −253°C was 0 4; at 220°C, 1 2 at 3100 AU. The change in a remains nearly proportional to the temperature change. (*Author's abstract*)

Discussed by Messrs BRICKWEDDE and TUCKERMAN

F. G BRICKWEDDE *A hydrogen isotope of mass 2 and its concentration.*—Last summer Birge and Menzel suggested the possible existence of an isotope of hydrogen with mass number two (H^2) to explain the difference between the atomic weights of hydrogen as determined chemically and by Aston using the mass spectrograph when reduced to a common basis. Isotopes of hydrogen with mass numbers two and three and helium five are needed to give regular arrangements of atomic nuclei a completed appearance when extrapolated to smallest atomic weights.

A calculation of the vapor pressures of pure isotopic crystals of the different molecular species H^1H^1, H^1H^2, H^1H^3 yield values of the vapor pressure which are in the ratio of 1 0 37 0 30 at 14°K, the triple point for ordinary hydrogen. Although a calculation for the liquid state was not possible it did seem reasonable to believe that heavier isotopic molecules if present should be rapidly concentrated in a residue of liquid hydrogen evaporated at the triple point Samples of hydrogen were prepared in the Cryogenic Laboratory of the Bureau of Standards from the residue of four to six liters of liquid evaporated at the normal boiling point and triple point These samples were examined with a grating spectrograph by Prof Harold C. Urey and Dr. G M Murphy at Columbia University for the visible atomic Balmer Series lines of hydrogen atoms with masses two and three, the wave-lengths of the new lines being calculated in advance of the measurements It was found that the known lines $H\alpha$, $H\beta$, $H\gamma$, and $H\delta$ are accompanied on the short wave-length side by weak lines agreeing within experimental error (about 0 02AU) with the calculated wave-lengths for an isotope of mass two, the corresponding H^1 and H^2 lines differing in wave-length by between 1 and 2 AU. The $H^2\alpha$ line was resolved into a doublet with a separation agreeing with that for the known $H^1\alpha$ line. The isotopic lines are not as diffuse as the known H^1 lines, probably due to a smaller Doppler broadening The isotopic lines

were found in ordinary hydrogen with an intensity of about 1/4000th the intensity of the H^1 lines, which yields a value for the ratio of H^2 to H^1 atoms in ordinary hydrogen of 1 to 4000

The sample prepared from six liters of liquid by evaporation at the normal boiling point showed no increase in the concentration of the isotope, indicating that the vapor pressures of the pure isotopic liquids at 20°K are the same In one sample prepared from four liters of liquid hydrogen evaporated at the triple point the concentration of the isotope was increased about 700 per cent These increases in concentration which are larger than have been attained before for any isotope made possible the positive identification of the isotope

No evidence for H^3 was found. (*Author's abstract*)

Discussed by Messrs UREY, MOHLER, HAWKESWORTH, GISH, BLAKE, CRITTENDEN, CURTIS, GIBSON, and TUCKERMAN.

1033D MEETING

The 1033rd meeting was held in the Cosmos Club Auditorium, Saturday evening, February 13, 1932. The meeting was called to order at 8 15 P M by President TUCKERMAN.

Program ROSS GUNN *The evolutionary origin of the solar system* —A new account for the formation of the solar system, based on the rotational evolution of a single parent star, is given which describes the system in some detail and avoids the major difficulties encountered by earlier investigators Electric and magnetic forces acting on the ions of a star's atmosphere determine its motion and stability, and permit the angular velocity of the star to increase until the star breaks into two component stars of comparable mass The hot face of each component star which has just emerged from the deep interior of the parent star loses momentum by radiation more rapidly than the cool face and kinetic energy and angular momentum are added to the star pair in such a way as to form a stable binary system It seems probable that the mechanism will separate the stellar components to infinity in a great many cases and two single stars produced Applying this to the solar system the Sun is supposed to have divided and lost its companion While each component star was inside the Roche limit of the other, centrifugal and tidal forces broke off the planets These in turn broke up for the same reason and produced the planetary satellites Tides and tidal couples transferred the momentum of axial spin of the two component stars to that of orbital momentum, leaving the Sun rotating very slowly The planets, because of their small size, largely escaped this process and originally rotated on their axes with a period approximating the critical period of the parent star. The birth of the Moon and its relative size compared to the Earth is well explained by the theory. The account replaces the earlier improbable and "accidental" theory by a systematic evolutionary process that may be quite common in the universe (*Author's abstract*)

Discussed by Messrs WHITE, HECK, HUMPHREYS, HAZARD, CURTIS, L H. ADAMS, STIMPSON, and TUCKERMAN.

L H ADAMS *The solidification of the earth*

Discussed by Messrs HAWKESWORTH, WHITE, HECK, CURTIS, HUMPHREYS, GIBSON, and TUCKERMAN

1034TH MEETING

The 1034th meeting was held in the Cosmos Club Auditorium, Saturday evening, February 27, 1932 The meeting was called to order at 8.20 P.M by Vice President O. S ADAMS

Program: R J SEEGER. *The growth of the electron concept in physics.* Discussed by Messrs CURTIS, HEYL, and GIBSON

D L WATSON *Biological organization as a physico-chemical problem*—G N Lewis has said that "living creatures are cheats in the game of physics and chemistry" From the standpoint of physics the problem of biological organization is to determine statistically, what is the nature of this cheating.

Organization, in an otherwise random system, can be discerned by (*a*) it strikes the attention of the observer and makes the distribution of the parts easier to apprehend, (*b*) its nature implies some specific *purpose* for which the system may be used Entropy, as a measure of physical organization, does not aid in the analysis of complex structures such as used in physical research, engineering or living matter It applies only to simpler, quasi-isotropic systems and measures only the special kind of organization whose purpose is to perform work on outside systems

The classical meaning of entropy arises through the Boltzmann formula and therefore through the probability concept The probability of a state, however, is a function of the method of classification applied to the system and therefore of the means available for observing the possible configurations Thus the subjective aspect of our apprehension of organization (mentioned above) can, in the cases in which we are interested, influence the value of the probability and (in a sense) the value of something-corresponding-to-the-entropy This conclusion is implied in the recent work of G N Lewis and P W Bridgman From this point of view, the Second Law requires merely that changes take place from easily classified states to less easily classified states If entropy measures only one kind of organization, an extension of the entropy concept or a new measure of organization is necessary for biology

Organization of biological systems is produced by key structures which we can call "selecting mechanisms" These produce a steady warping of the statistics of the assembly in which they occur New classifications, unfamiliar in theoretical physics, are more readily adapted to these "warped" configurations, and this is the nature of the "cheating" to which Lewis refers Such selecting mechanisms can appear spontaneously under suitable physical and chemical conditions Intelligence is not necessary In any case, mechanical selecting devices having more and more of the characteristics of intelligent beings are becoming commoner, both in engineering and experimental psychology (*Author's abstract*)

Discussed by Mr GIBSON

Informal communication W J HUMPHREYS *The colder the air the thinner the ice*—It is a saying among certain Great Lakes fishermen that ice grows faster in zero (Fahrenheit) weather than it does when the temperature is considerably subzero This, if true, is one of nature's many paradoxes, one of her pleasing puzzles which it always is a delight to solve But is it true?

Evidently the rate of thickening of the ice (at the under surface of course) is proportional to the rate of loss of heat by the water up through the ice cover Under steady conditions this rate in turn is proportional directly to the thermal conductivity of the ice and the difference in temperature between its upper and under surfaces, and indirectly to the thickness of the ice sheet In other words, it is proportional to the conductivity of the ice and the temperature gradient through it Now the conductivity of ice is a constant, nearly, if we neglect, or take into account and average, the effect of air bubbles and other irregularities Also the temperature at the under surface of the ice is a constant, namely, 32°F in the case of fresh water. We, therefore, can say that for any given thickness of the ice, the rate of its further

growth, under steady conditions, is directly proportional to the extent to which the temperature of its outer surface is below the freezing point That is, it is proportional to $32 - t_s$, in which t_s is the temperature, as indicated by a Fahrenheit thermometer, of the upper surface If, then, this upper surface always had the temperature of the air above it, there would be no occasion to explain the paradox in question for there would be no paradox But this relation does not always hold and in that fact we have the solution of our fisherman's puzzle

At temperatures around zero Fahrenheit there is not likely to be much fog drifting over the ice from the open water farther out in the lake, and often too at such times there is wind enough to keep the surface of the ice swept clean of snow On the other hand, when the temperature of the air is considerably lower the "frost smoke," produced by the "steaming" of the open, deep water and remaining unevaporated at the low temperature, well may spread out slowly over the ice and thereby not only decrease the net loss of heat by radiation, as fogs and clouds always do by the return radiation they themselves give out, but also decrease it, sometimes very greatly, by depositing over the ice an insulating sheet of finely powdered snow Any substance, even a metal, when finely divided, is a poor conductor of heat, and snow is one of the poorest Hence ice covered with a layer of fine snow, even though that layer be very thin, loses heat to colder air above much more slowly than it would if bare Obviously, therefore, under otherwise like conditions ice increases in thickness much faster when bare than it does when snow covered

Ice of any given thickness grows fastest when its surface is coldest, but this temperature depends in part on the condition of the air above—clear, cloudy, or foggy—and on the condition of its surface, clean or snow covered And the fog blanket and the fine snow cover are most likely to form in relatively calm and very cold weather, drifted by the gentle movement of the air that commonly obtains on such occasions over and onto the ice sheet to the leeward of the remaining open water

It well may be, therefore, as fishermen tell us, that at certain places, at least, along the shores of the Great Lakes, more ice is formed occasionally, perhaps also on the average, when the temperature of the air is around zero Fahrenheit than there is when that temperature is even 20° to 30° lower, owing, as explained, to the greater prevalence of clear air and clean ice in the first case and foggy air and snowy ice in the second

But here also, as everywhere and always, a few appropriate figures afford a very necessary check on one's general or qualitative reasoning Let the conditions be

a Temperature of the air −18°C, 0°F, approximately,
Thickness of ice, 5, 10, 25, 50 centimeters, respectively
Snow covering, none

b Temperature of the air −29°C, −20°F, roughly.
Thickness of ice, as in cases *a*
Snow covering, 1 millimeter.

c Same as *b* in respect to temperature of air and thickness of ice
Snow covering, 5 millimeters

Now since the radiations of snow and ice at these low temperatures are small, the reflection of sunlight and skylight by snow roughly 90 per cent; the amount of such radiation absorbed by ice also small, especially since there is not likely to be much of it to absorb in mid-winter at latitude 47° N., say, and the heat conductivity of ice very low, therefore, as a first approxima-

tion, we may assume the temperature of the top surface of the snow, or bare ice, to be that of the adjacent air. The temperature of the under surface of the ice is, of course, 0°C Furthermore, as experiment has shown, the conductivity of very loose snow may be as low as one three-hundredth that of ice Assume it, in the present case, to be one one-hundredth that value, so that, as a heat insulator, a layer of our fine snow one millimeter deep is the equivalent of a sheet of ice 100 times as thick—10 centimeters; a 5 millimeter covering of snow the equivalent of a 50 centimeter sheet of ice; and so on for other depths and thicknesses

In case *a* the difference in temperature between the under and upper surfaces of the ice is 18°C, and in cases *b* and *c* the difference between the temperature of the under surface of the ice and top surface of the snow 29°C. Therefore our various temperature gradients, in terms of centigrade degrees and thicknesses, or equivalent thicknesses, in centimeters, of ice are as given in the following table

Temperature Gradients

Thickness of ice, cm	5	10	25	50
Bare Air −18°C	$\frac{18}{5}$	$\frac{18}{10}$	$\frac{18}{25}$	$\frac{18}{50}$
1 mm snow Air −29°C	$\frac{29}{15}$	$\frac{29}{20}$	$\frac{29}{35}$	$\frac{29}{60}$
5 mm snow Air −29°C	$\frac{29}{55}$	$\frac{29}{60}$	$\frac{29}{75}$	$\frac{29}{100}$

From these gradients it is clear that often bare ice can grow faster when the temperature of the air is 0°F than can snow covered ice of the same thickness when the air is much colder, even −20°F When the thickness of the ice is 16 3 centimeters (6 4 inches) it grows just as fast in 0°F. weather, if bare, as it would with a 1 mm covering of loose snow (conductivity of snow one one-hundredth that of ice) in weather at −20°F If thinner, the bare ice would grow faster than the snow covered at the given temperatures, and if thicker it would grow slower If the depth of the snow were 5 mm the thickness of the ice would need to be 81 8 centimeters (32 2 inches) for the rates of growth, under the given conditions, to be the same.

In the first of these cases the rate of increase of thickness is about one centimeter in 4 hours, the conductivity of ice being 0 005 (transmitting 0 005 calorie per second per square centimeter cross-section when the temperature gradient is 1°C per centimeter), and in the second case one centimeter in 20 hours

Thus the fisherman's interesting paradox, the colder the air the thinner the ice, has become orthodox and lost its fascination. (*Author's abstract*)

1035TH MEETING

The 1035th meeting was held in the Cosmos Club Auditorium, Saturday evening, March 12, 1932. The meeting was called to order at 8 18 P M by President TUCKERMAN.

Program: F K. HARRIS *Application of the cathode-ray oscillograph*—The sensitivity of cathode-ray oscillographs and the upper limit of their range

of usefulness in high-frequency recording were discussed The application of the oscillograph to the investigations of transmission-line transients initiated by lightning, and the use of the oscillograph as a recording wattmeter were discussed in some detail (*Author's abstract*)

Discussed by Messrs WENNER, GISH, CURTIS, and HUMPHREYS

P. R. HEYL: *Cause or chance?* The past third of a century has called into question and modified or discarded most of the theoretical principles of physical science which had formerly been regarded as permanently established. It has been reserved for the last few years to attack what has always been regarded as the most fundamental principle of all, for there has come a change in the scientific attitude toward the law of cause and effect This latest skepticism concerns itself principally with the behavior of electrons The new philosophy asserts that the future course of an electron is a matter not for definite prediction, but only of statistical probability

There is an imposing array of authority on the side of this new and strange doctrine—Bohr, Heisenberg, Dirac, Jordan, Born, Eddington, and others, while the opposition can name but one physicist of the same rank—Planck.

Those who have adopted this position have done so because of the increasing difficulty of giving a satisfactory explanation of electronic phenomena in terms of the classical frame of space-time It appears that a probability-interpretation of the equations of wave mechanics avoids all the present difficulties. On this interpretation, causal laws are replaced by laws of probability. (*Author's abstract*)

Discussed by Messrs BRICKWEDDE, HORST, HUMPHREYS, and LITTLEHALES

Informal communications P. R HEYL described a method of testing character of knife-edges by a balance method

Discussed by Messrs WENSEL, LITTLEHALES, WHITE, and HUMPHREYS

H. L CURTIS described a mechanical wave filter for low frequencies.

1036TH MEETING

The 1036th meeting was held in the Cosmos Club Auditorium, Saturday evening, March 26, 1932 The meeting was called to order at 8 15 P M by President TUCKERMAN

Program: J E IVES: *The physicist in public health work* —The important part played in preventive medicine, and particularly in industrial hygiene, by the physicist, was emphasized Medicine is interested in the relation of man to his physical environment, to radiation, to the temperature, humidity, velocity, and ionization of the air, and to the dust-content of the air The physician determines the intracorporeal quantities such as blood pressure, body temperature, pulse rate, etc, while the physicist determines the extracorporeal quantities, such as temperature and velocity of the air, and intensity of radiation (ultraviolet, visible, and infrared)

In industrial hygiene, the illumination, both natural and artificial, of workshops is of importance, involving the size and location of windows, and the location of lighting units Certain intensities of lighting are necessary to protect the eye, and to promote industrial efficiency

Ventilation of shops and factories is also of importance from the hygienic point of view.

In private dwellings, spacing, lighting and air-conditioning call for the knowledge of the physicist as well as that of the physician. The best size of room, and height of ceiling, involve problems both for the physiologist and the physicist

Radiation has many problems in which both the physicist and the physi-

cian are interested, such as the properties of therapeutic lamps, the transmission of ultraviolet rays by window glass, radiation of infrared rays from molten iron and glass, and of the less intense infrared radiation from the ceilings and walls of houses and schoolrooms, and the effect of these radiations upon the body and the eyes (*Author's abstract.*)

Discussed by Messrs TUCKERMAN, RAMBERG, HAWKESWORTH, BLAKE, and HECK.

F. S BRACKETT· *The division of radiation and organisms of the Smithsonian Institution*

Discussed by Dr IVES

Informal communication. R. B. KENNARD described an apparatus for measuring small pressure-differences and small velocities of a gas The apparatus consisted essentially of a manometer with means provided for making accurate readings The apparatus was placed on exhibition before the Society

1037TH MEETING

The 1037th meeting was held in the Cosmos Club Auditorium, Saturday evening, April 9, 1932 The meeting was called to order at 8·15 P.M by President TUCKERMAN

Program R B KENNARD —*The interferometer as an instrument for measuring air temperatures near heated surfaces*

Discussed by Messrs WHITE, TUCKERMAN, and WENSEL

WM F ROESER· *Reference curves for use with thermocouples* —Reference tables for thermocouples give a relation between electromotive force and temperature These tables in conjunction with suitable deviation curves, serve as a convenient means of interpolating between calibration points and converting readings of electromotive force to temperature

It has been found advisable to revise the classic table prepared by Adams for the standard platinum to platinum-10% rhodium thermocouple to make it conform to the present temperature scale Careful study of ten representative couples, moreover, indicated that the thermocouples of this type used today do not have exactly the same characteristics as those upon which Adams' table was based The principal change made in Adams' table for platinum to platinum-10% rhodium thermocouples was at temperatures above the gold point (1063°C) The maximum change below 1200°C was 0 5°C, whereas the change at 1500°C was 4°C

New tables were also prepared for platinum to platinum-13% rhodium thermocouples and for several couples of base-metal alloys (*Author's abstract*)

Discussed by Messrs L H ADAMS and WHITE

Informal communication W P WHITE discussed his experiences and difficulties in calibrating thermocouples

Discussed by Messrs ROESER and WENSEL

C GOLDENBERG described and gave an explanation of two smoke puffs from large guns.

1038TH MEETING

The 1038th meeting was held in the Cosmos Club Auditorium, Saturday evening, April 23, 1932 The meeting was called to order at 8 30 P.M by President TUCKERMAN

Program Prof. A. E KENNELLY: *The work of Joseph Henry in relation to applied science and engineering.* The Joseph Henry lecture, published in this JOURNAL **22**: 293.

1039TH MEETING

The 1039th meeting was held in the Cosmos Club Auditorium, Saturday evening, May 7, 1932. The meeting was called to order at 8 15 P.M. by President TUCKERMAN.

Program· RICHARD COURANT: *Alternating electric currents in the earth and their application*

Discussed by Messrs HAWKESWORTH, GISH, RAMBERG, GIBSON, DANTZIG, and TUCKERMAN

Informal communication O H GISH reported upon the phenomenon of earth-currents flowing consistently upward towards the top of hills and mountains An explanation for this phenomenon was suggested based upon systematic differences in hydrogen-ion concentration between the top and bottom of the hills and mountains.

1040TH MEETING

The 1040th meeting was held in the Cosmos Club Auditorium, Saturday evening, May 21, 1932 The meeting was called to order at 8 15 P M by President TUCKERMAN.

The proposed changes in by-laws, recommended at a special business meeting of the General Committee called by the President on May 5, were voted upon at this meeting and adopted as follows

Article I, Sec 6, after "Treasurer," first line, insert "or in his absence or inability to act, the Acting Treasurer provided for in Article I, Sec 7"

Add, Article I, Sec 7, "The general Committee shall have power to designate any one of its members except the President, a Vice-President or a Secretary as Acting Treasurer to serve during the absence of the Treasurer or his inability to act"

The purpose of the above amendments is to make it possible, especially during the present depression, for changes to be made in the Society's investments in case of an emergency during the absence or illness of the Treasurer, who now is the only person having access to the Society's securities

Program. H. H KIMBALL *Solar radiation as a meteorological factor* — Variations in the Earth's solar distance cause variations in the intensity of solar radiation at the outer limit of the Earth's atmosphere of very nearly 3 5 per cent on each side of the mean, with the maximum early in January and the minimum early in July

Variations in solar declination cause seasonal variations in the daily totals of solar radiation as measured at the surface of the Earth, which are small at the equator, but increase rapidly with latitude At Havana, Cuba, latitude 23° 09′N , the average daily amount at the time of the summer solstice is about double that at the time of the winter solstice, at Washington, D C , latitude 38° 56′N , the corresponding ratio is about 3 5, at Stockholm, Sweden, latitude 59° 21′N , it is about 20, and at Sloutzk, U S S R , about 40

Following explosive volcanic eruptions the great quantity of dust thrown into the atmosphere, some of it to great heights, has diminished the intensity of the direct rays of the Sun as received at the Earth's surface from 15 to 25 per cent for periods of several months Such explosions, with their accompanying dust-clouds, occurred in 1883, 1888–1891, 1902, and 1912, and a slight cooling of the Earth as a whole seems to have followed On the other hand, there have been no such eruptions since 1912, or during a period of nearly 20 years, and Angstrom is of the opinion that on account of the small amount of dust now present in the stratosphere the temperature of the Earth should be slightly higher than usual

For solar constant values it has been claimed that periodicities of from 68 to 8 months exist, with amplitudes of from 0.005 to 0.014 calories, or about 0.3 to 0.7 per cent of the mean value. Also, that there are short-period trends in values, with an average length of 5 days and an average amplitude of 0.8 per cent. To these short-period trends of less than one per cent in magnitude, have been attributed the *major changes in weather.*

A careful study of these various variations in the intensity of solar radiation leads to the conclusion that weather changes are brought about, not by short-period trends of less than one per cent, but by the many-fold difference in the intensity of the solar radiation received by the Earth in equatorial and polar regions. As a result great temperature differences exist between these regions. Gravity causes the heavy cold air to displace the lighter warm air at the surface, and a polar-equatorial circulation is set up, turbulent in character, especially in winter when the temperature difference is most marked. Well-defined movements of this character are to be found on the weather maps of the different countries, and examples are shown in this paper in reproductions of weather maps for the United States. It is to studies of this turbulent polar-equator movement of air that meteorologists look for improvements in weather forecasting, and it is for such studies that the meteorological work of the *Jubilee International Polar Year 1932–1933* is now being organized.

As stated by the Chairman of the Commission for the Polar Year, "The further that extensions have been made of the dynamical theories of air interaction in moderate latitudes for practical forecasting purposes, the clearer has it become that atmospheric processes in the polar regions of both hemispheres play a predominant part. These regions are very often the source of the surges in the atmosphere whose necessary outcome are the weather variations at low latitudes. An intimate study, therefore, of the behavior of the atmosphere in high latitudes has now become a necessity for the extension in knowledge of weather processes." (*Author's abstract.*)

Discussed by MERWIN, CURTIS, HUMPHREYS, LITTLEHALES, GIBSON, and HAZARD.

W. J. HUMPHREYS: *If Greenland's ice should melt.*—If all the ice on Greenland should melt, so also would the ice on Antarctica and every part of the world. From recent depth soundings of this ice, and from other evidence, it seems that the melting of it all would raise the level of the oceans about 150 feet. This would be a calamity of the highest order, since it would mean the abandonment of many great cities and much rich coastal land. Furthermore, the melting of the ice would cause profound climatic changes. Storms then, owing to the relatively small temperature contrast between poles and equator, would be few and feeble, and mainly pass at much higher latitudes than they now do. Hence all mid-latitude regions would then be semi-arid to desert.

This disastrous condition, which appears to have been the world's normal state through much the greater part of its history, may again be upon us in only a few thousand years, and will be if the ice continues to melt in the future as, on the average, it has melted since the maximum advance of the last glacial sheets, some 30,000 years ago. Of course, the retreat of the ice may cease at any time and a greater or less advance begin. That often has happened, and an advance could now be started by certain minor geologic changes.

Presumably a number of suitably installed and properly located gages would soon tell us definitely how fast the oceans are filling up; how rapidly, therefore, the ice is melting, and how swiftly the world is passing into its customary semi-arid and more or less desolate state. (*Author's abstract.*)

Discussed by Messrs LITTLEHALES, TUCKERMAN, CURTIS, DRYDEN, and WRIGHT.

G. R. WAIT, *Recording Secretary.*

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GEOPHYSICS.—*On the flow of heat from a rock stratum in which heat is being generated.*[1] C. E. VAN ORSTRAND, U. S. Geological Survey.

Numerous investigators have made the assumption that heat is developed in certain formations, particularly in oil sands. A possible test of this hypothesis consists in comparing the theoretical depth-temperature curves obtained on the basis of a generation of heat in a single stratum with the observed depth-temperature curves. Stated geologically, the problem is this

Let it be assumed for convenience that the earth is a cooling globe and that the strata are parallel to the horizontal surface of the ground. After the lapse of several hundreds of millions of years t_1, heat is supposed to be developed in one of the thin horizontal layers at a constant or variable rate for a very long interval of time t. It is required to determine the nature of the depth-temperature curves after the earth has cooled for $t_1 + t$ years, during which time heat was developed in one of the strata for the last t years of the period $t_1 + t$.

Mathematically, we have to determine the solution for the semi-infinite solid subject to the conditions —

$$\begin{array}{llll} v = f_1(x) & \text{when } t_1 = 0 & \text{and } x \geqq 0 & \\ v = f(x) & \text{“} \quad t_1 = t_1 & \text{“} \quad x \geqq 0 & \\ v = f(x) & \text{“} \quad t = 0 & \text{“} \quad x \geqq 0 & \\ v = 0 & \text{“} \quad t_1 \geqq 0 & \text{“} \quad x = 0 & (1) \\ v = 0 & \text{“} \quad t \geqq 0 & \text{“} \quad x = 0 & \\ v = \phi(t) & \text{“} \quad t \geqq 0 & \text{“} \quad x = x' & \end{array}$$

These equations and inequalities state that a permanent heat source, $v = \phi(t)$, is maintained at a distance x' from the face of the slab, that the surface of the slab, $x = 0$, is maintained at constant tempera-

[1] Published by permission of the Director, U. S. Geological Survey Received August 12, 1932

ture, $v = o$, for all values of the time; and that the temperature distribution in the slab at the time, $t = o$, when heat is first generated in the slab is, $v = f(x)$. This relation results from the cooling of the slab from the initial temperature distribution, $v = f_1(x)$, through the time interval t_1. That is, in the course of t_1 years, the function, $v = f_1(x)$, becomes, $v = f(x)$, which is now the temperature distribution in the slab at the time $t = o$.

In addition to satisfying conditions (1), it is necessary to satisfy the fundamental equation of heat conduction, namely,

$$\frac{\partial v}{\partial t} = \kappa \frac{\partial^2 v}{\partial x^2} \tag{2}$$

in which κ is the coefficient of diffusivity of the rocks above and below the plane, $x = x'$, on which the heat is supposed to be concentrated. To be strictly accurate, the thickness of the heat-generating bed should be taken into account, but inasmuch as the distances traversed by the heat are very great in comparison with the thickness of the bed, it will suffice for a first approximation to assume that all of the heat generated in the bed is concentrated on the plane, $x = x'$, from which it flows in both directions.

Various methods of procedure are possible. Let us adopt the method of heat sources in which sources of negative intensity (sinks) in the negative portion of the plane correspond to equal positive sources in the positive portion of the plane The solution consists in performing the summations for all of the sources and sinks from $x = +\infty$ to $x = -\infty$.

That portion of the solution in which the instantaneous heat sources and sinks represent the arbitrary temperature distribution, $v = f_1(x)$, when the earth first began to cool is given by the equation[2]

$$v_1 = \frac{1}{2\sqrt{\pi \kappa t_1}} \int_0^\infty f_1(\lambda) \left[e^{-\frac{(\lambda - x)^2}{4\kappa t}} - e^{-\frac{(\lambda + x)^2}{4\kappa t}} \right] d\lambda \tag{3}$$

Now let us assume that the earth cooled from an initial temperature, v_o, then $v_o = f_1(x)$, and (3) becomes

$$v_1 = f(x) = t_0 \cdot \frac{2}{\sqrt{\pi}} \int_0^{\frac{x}{2\sqrt{\kappa t_1}}} e^{-\beta^2} d\beta \tag{4}$$

To this equation, calculated for the time interval $t_1 + t$, we must add the rise in temperature due to the single heat source at $x = x'$.

[2] L R INGERSOLL and O J ZOBEL *An introduction to the theory of heat conduction* (Ginn and Co) pp 76–77

In order to maintain a constant zero temperature at the surface of the earth, we must add an equal sink at $x = -x'$. Hence we have for the instantaneous source and sink

$$v = \frac{v_q}{2\sqrt{\pi\kappa t}}\left(e^{-\frac{(x'-x)^2}{4\kappa t}} - e^{-\frac{(x'+x)^2}{4\kappa t}}\right) \tag{5}$$

in which $\phi(t)$ has been replaced by v_q, where

$$v_q = q/\rho c \tag{6}$$

is the rise in temperature in 1 cc of rock at the source, density ρ, specific heat c, due to the development of q calories of heat per sq. cm. per sec. on the plane, $x = x'$.

The permanent source and sink resulting from (5) is

$$v_2 = \frac{v_q}{2\sqrt{\pi\kappa}}\int_0^t \frac{e^{-\frac{(x'+x)^2}{4\kappa(t-t')}}\,dt'}{\sqrt{t-t'}} - \int_0^t \frac{e^{-\frac{(x'-x)^2}{4\kappa(t-t')}}\,dt'}{\sqrt{t-t'}} \tag{7}$$

To integrate (7), put

$$\beta^2 = \frac{(x'-x)^2}{4\kappa(t-t')} \qquad \beta^2 = \frac{(x'+x)^2}{4\kappa(t-t')}$$

then we have

$$dt' = 2(t-t')\frac{d\beta}{\beta} \qquad dt' = 2(t-t')\frac{d\beta}{\beta}$$

Substituting these expressions in the respective terms of (7),

$$v_2 = \frac{v_q}{2\kappa\sqrt{\pi}}\left[(x'-x)\int_{\frac{x'-x}{2\sqrt{\kappa t}}}^{\infty}\frac{e^{-\beta^2}\,d\beta}{\beta^2} - (x'+x)\int_{\frac{x'+x}{2\sqrt{\kappa t}}}^{\infty}\frac{e^{-\beta^2}\,d\beta}{\beta}\right] \tag{8}$$

in which the indeterminate form in the upper limit has been put equal to ∞.

Making use of the relations,

$$\int_x^\infty x^n e^{-ax^2}\,dx = +\frac{1}{2a}x^{n-1}e^{-ax^2} +$$

$$\frac{n-1}{2a}\int_x^\infty x^{n-2}e^{-ax^2}\,dx. \quad a = 1, n = 0$$

and

$$2\int_x^{\infty} e^{-x^2}\,dx = \sqrt{\pi}\cdot\frac{2}{\sqrt{\pi}}\int_x^{\infty} e^{-x^2}\,dx$$

$$= \sqrt{\pi} = \sqrt{\pi}\quad\frac{2}{\sqrt{\pi}}\int_0^{x} e^{-x^2}\,dx$$

we have for the integral

$$\begin{aligned} v_2 = v_q \Bigg\{ & \frac{\sqrt{t}}{\sqrt{\pi\kappa}}\left[e^{-\frac{(x'-x)^2}{4\kappa t}} - e^{-\frac{(x'+x)^2}{4\kappa t}}\right] \\ & + \frac{x}{\kappa} + \frac{(x'-x)}{2\kappa}\cdot\frac{2}{\sqrt{\pi}}\int_0^{\frac{(x'-x)}{2\sqrt{\kappa t}}} e^{-\beta^2}\,d\beta \\ & - \frac{(x'+x)}{2\kappa}\cdot\frac{2}{\sqrt{\pi}}\int_0^{\frac{x'+x}{2\sqrt{\kappa t}}} e^{-\beta^2}\,d\beta\Bigg\} \\ = {} & v_q\,\alpha \end{aligned}$$

in which the contribution from the source is (9)

$$\begin{aligned} u_1 = v_q\Bigg[& \frac{\sqrt{t}}{\sqrt{\pi\kappa}}\,e^{-\frac{(x'-x)^2}{4\kappa t}} - \frac{(x'-x)}{2\kappa} \\ & + \frac{(x'-x)}{2\kappa}\cdot\frac{2}{\sqrt{\pi}}\int_0^{\frac{(x'-x)}{2\sqrt{\kappa t}}} e^{-\beta^2}\,d\beta\Bigg] \end{aligned} \tag{10}$$

and the same for the sink is

$$\begin{aligned} u_2 = v_q\Bigg[& \frac{\sqrt{t}}{\sqrt{\pi\kappa}}\,e^{-\frac{(x'+x)^2}{4\kappa t}} - \frac{(x'+x)}{2\kappa} \\ & + \frac{(x'+x)}{2\kappa}\cdot\frac{2}{\sqrt{\pi}}\int_0^{\frac{(x'+x)}{2\sqrt{\kappa t}}} e^{-\beta^2}\,d\beta\Bigg] \end{aligned} \tag{11}$$

As the numerical value of u_1 in the negative portion of the plane is the same as that of u_2 in the positive portion of the plane, it follows that our problem is the same as that of a source at $x = x'$ and a perfect absorber of heat at $x = o$ in the sense that the heat which reaches the surface of the ground is lost to the system. In their interesting and

important researches on the diffusion of substances, Stefan[3] and Roberts-Austen[4] assumed that a plane surface perpendicular to the x-axis at the origin acts as a perfect reflector in which case that portion of the curve in the negative part of the plane is considered to be positive instead of negative.

The required temperature is

$$v = v_1 + v_2 \tag{12}$$

The value of the time required in computing v_1 from (4) is $t_1 + t$. Making the appropriate substitutions in (4) and (9) it is found that all of the conditions in (1) are satisfied and as each source and sink is an integral of (2), it follows that the summation of these terms likewise satisfies (2). Carslaw[5] gives a solution similar to (12) when the source $\phi(t)$ is at the origin. Wright[6] discusses the same problem when the initial temperature of the semi-infinite solid is zero.

Equation (9) holds between the limits $x = o$ and $x = x'$ Interchanging x and x' in (8) and carrying out the usual integrations, we have

$$\begin{aligned} v_2 = u_1 - u_2 = v_q \Bigg\{ & \frac{\sqrt{t}}{\sqrt{\pi\kappa}} \left[e^{-\frac{(x-x')^2}{4\kappa t}} - e^{-\frac{(x+x')^2}{4\kappa t}} \right] \\ & + \frac{x'}{\kappa} + \frac{(x-x')}{2\kappa} \cdot \frac{2}{\sqrt{\pi}} \int_0^{\frac{x-x'}{2\sqrt{\kappa t}}} e^{-\beta^2}\, d\beta \\ & - \frac{(x+x')}{2\kappa} \cdot \frac{2}{\sqrt{\pi}} \int_0^{\frac{x+x'}{2\sqrt{\kappa t}}} e^{-\beta^2}\, d\beta \Bigg\} \end{aligned} \tag{13}$$

Equation (13) is to be used instead of equation (9) between the limits $x = x'$ and $x = +\infty$. In the limit, when $t = \infty$, equations (9) and (13) give for the final temperature distribution

$$v = v_q x/\kappa \qquad x = \text{o to } x = x' \tag{9a}$$

$$v = v_q x'/\kappa \qquad x = x' \text{ to } x = \infty \tag{13a}$$

[3] M J STEFAN *Über die Diffusion der Flussigkeiten* K Akad Wiss Wien Sitzungsber **79**: 161–214 1879

[4] W C ROBERTS-AUSTEN *On the diffusion of metals* Roy Soc London Phil Trans **187***A* 383–415 1896

[5] H S CARSLAW *The conduction of heat* (Macmillan Co 1921) p 173

[6] C E WRIGHT *Note on a problem in the conduction of heat* Phil Mag **12**: 1015–1019 1931

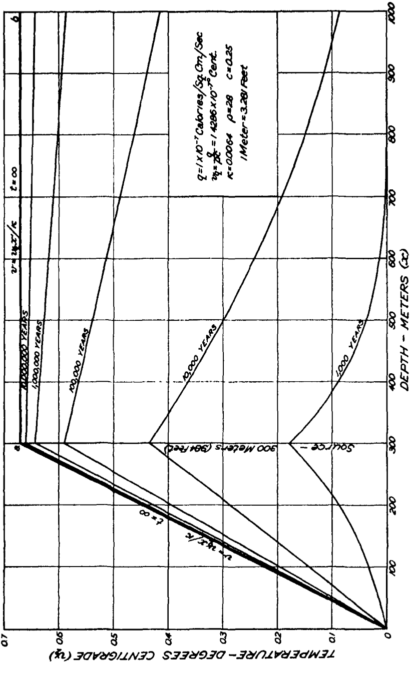

Fig 1 —Rise in temperature due to a heat source at depth of 300 meters

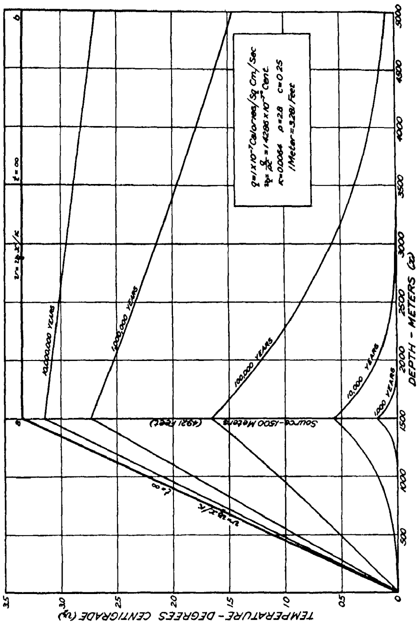

Fig 2 —Rise in temperature due to a heat source at depth of 1500 meters

These equations are represented in Figures 1 and 2 by the respective lines, *oa* and *ab*. In the latter case, $\partial v/\partial x = 0$, and heat has ceased to flow from the source in the direction of increasing values of x. From (6), (9*a*), and the relation, $\kappa = k/\rho c$, where k is the coefficient of thermal conductivity, the flow of heat across a plane perpendicular to the depth axis between $x = x'$ and $x = o$ is

$$k \frac{\partial v}{\partial x} = \frac{k v_q}{\kappa} = q$$

that is, in the limiting state, the quantity of heat per unit time per unit area escaping from the surface of the earth is the same as the quantity of heat generated per unit time per unit area on the plane, $x = x'$. In the case of a bed of thickness n centimeters,

$$k \frac{\partial v}{\partial x} = \frac{k n v_q}{\kappa} = nq$$

and the temperature at the top of the bed, depth x', is

$$v = x' \frac{\partial v}{\partial x} = \frac{x' n q}{k}.$$

From the bottom of the bed, $x' + n$, to the point $x = +\infty$, the temperature is approximately

$$v = \frac{x' n q}{k} + \frac{n(n+1)q}{2k}.$$

Tables 1 and 2 contain the coefficients α of v_q in equations (9) and (13) computed for permanent heat sources at $x' = 300$ meters $= 984$ feet, and $x' = 1500$ meters $= 4921$ feet, for $t = 1000$ years, 10,000 years and so on. The products of these coefficients α and v_q represent temperatures on the centigrade scale when q is expressed in calories per square centimeter per second. The last digit in the tabulations may not be correct

The curves in Figures 1 and 2 show the rise in temperature (v_2) when $q = 1 \times 10^{-7}$ calories per sq. cm. per second, $\rho = 2.8$, $c = 0.25$, and $v_q = q/\rho c = 1\ 4286 \times 10^{-7}$°C. This value of q is the equivalent of 3 156 calories per year which is a close approximation to the value of 3.0 calories per year obtained by Richardson and Wells[7]

[7] L T Richardson and R C Wells *The heat of solution of some potash minerals* This Journal, 21· 243-248 1931

TABLE 1 VALUES OF α $x' = 300$ METERS = 984 FEET

DEPTH		$\alpha \times 10^{-3}$			DEPTH		$\alpha \times 10^{-3}$	
Meters	Feet	1,000 years	10,000 years	100,000 years	Meters	Feet	1,000,000 years	10,000,000 years
0	0	0	0	0	0	0	0	0
100	328	237	997	1377	300	984	4511	4632
200	656	617	2007	2755	500	1640	4393	4594
225	738	749	2263	3099	1000	3281	4101	4501
250	820	898	2521	3442	1500	4921	3816	4408
275	902	1065	2781	3788	2000	6562	3530	4318
300	984	1252	3042	4133	2500	8202	3254	4225
325	1066	1066	2916	4087	3000	9842	2986	4132
350	1148	900	2791	4041	3500	11483	2728	4040
375	1230	753	2669	3996	4000	13123	2481	3948
400	1312	623	2550	3951	4500	14764	2246	3857
500	1640	264	2101	3770	5000	16404	2023	3767
600	1968	94	1700	3591	5500	18045	1814	3676
700	2297	27	1351	3415	6000	19685	1619	3587
800	2625	7	1053	3242	6500	21325	1440	3499
900	2953	1	806	3073	7000	22966	1270	3411
1000	3281	0	605	2907	7500	24606	1116	3324
1100	3609		445	2745	8000	26247	976	3237
1200	3937		251	2587	8500	27887	849	3152
1300	4265		227	2434	9000	29527	735	3067
1400	4593		157	2286	9500	31168	633	2984
1500	4921		106	2143	10000	32808	542	2901
1600	5249		71	2005	10500	34449	461	2819
1700	5577		46	1872	11000	36089	393	2738
1800	5905		29	1745	11500	37730	328	2658
2000	6562		11	1507	12000	39370	276	2579
2500	8202		0	1009	13000	42651	192	2428
3000	9842			643	14000	45932	130	2279
3500	11483			388	15000	49212	85	2135
4000	13123			221	20000	65617	7	1498
4500	14764			121	25000	82021	1	1001
5000	16404			62	30000	98425	0	635
5500	18045			30	35000	114829		382
6000	19685			14	40000	131233		221
6500	21325			7	45000	147637		120
7000	22966			2	50000	164042		61
7500	24606			1	60000	196850		16
8000	26247			0	70000	229658		5
					80000	262467		2
					90000	295275		1

TABLE 2 VALUES OF α. $x' = 1500$ METERS $= 4921$ FEET

DEPTH		$\alpha \times 10^{-6}$		
Meters	Feet	1,000 years	10,000 years	100,000 years
0	0	0	0	0
250	820	0	83	1784
500	1640	0	243	3594
750	2461	0	580	5458
1000	3281	7	1222	7399
1250	4101	161	2311	9437
1400	4593	623	3229	10715
1500	4921	1253	3962	11592
1550	5085	901	3583	11257
1600	5249	623	3229	10928
1650	5413	415	2900	10603
1700	5577	264	2594	10284
1750	5741	161	2311	9971
1800	5905	94	2051	9663
1900	6234	27	1596	9064
2000	6562	7	1222	8480
2100	6890	1	919	7936
2200	7218	0	680	7408
2250	7382		580	7152
2300	7546		493	6902
2500	8202		246	5962
2600	8530		168	5526
2700	8858		113	5113
2750	9022		92	4915
3000	9842		30	4008
3250	10663		9	3232
3500	11483		2	2575
3750	12303		0	2029
4000	13123			1579
4500	14764			923
5000	16404			514
5500	18045			272
6000	19685			137
6500	21325			65
7000	22966			29
7500	24606			12
8000	26247			5
9000	29527			1
10000	32808			0

DEPTH		$\alpha \times 10^{-6}$	
Meters	Feet	1,000,000 years	10,000,000 years
0	0	0	0
500	1640	6356	7347
1000	3281	12721	14696
1500	4921	19104	22046
2000	6562	17700	21581
2500	8202	16330	21120
3000	9842	15000	20660
3500	11483	13719	20201
4000	13123	12490	19744
4500	14764	11319	19289
5000	16404	10211	18837
5500	18045	9169	18387
6000	19685	8193	17941
6500	21325	7287	17497
7000	22966	6449	17058
7500	24606	5680	16623
8000	26247	4977	16192
8500	27887	4339	15765
9000	29527	3765	15342
10000	32808	2789	14510
11000	36089	2024	13699
12000	39370	1438	12910
13000	42651	1000	12145
14000	45932	681	11400
15000	49212	454	10683
16000	52493	296	9992
17000	55774	187	9332
18000	59055	117	8694
19000	62336	71	8083
20000	65617	44	7505
25000	82021	2	5016
30000	98425	0	3185
35000	114829		1917
40000	131233		1097
45000	147637		596
50000	164042		303
60000	196850		63
70000	229658		12
80000	262467		4
90000	295275		4

as a possible value of the annual quantity of heat absorbed in the potash beds in Texas and New Mexico. For any other value of v_q, say v_q', and the same thermal constants, it is only necessary to multiply the ordinates of the curve by v_q'/v_q. In the case of absorption of heat, v_2 in (12) is negative.

With increasing depth of source, the curves for short intervals of time tend to become more and more symmetrical. The maximum temperature towards which the source constantly approaches is $v_q x'/\kappa$. These maxima are obviously points on the straight line, $v = v_q x/\kappa$.

For large values of v_q, and small intervals of time t, the curves show that the quantities v_2 which are to be added to or subtracted from the depth-temperature curve v_1 increase rapidly as the source is approached, showing a marked convexity of the curve towards the depth-axis, after which they drop less rapidly to a zero value. A large abnormality of this kind superposed on the depth-temperature curve v_1, which is practically a straight line, should be capable of detection in the field; but, with increasing time, regardless of the value of v_q, that portion of the curve over which it is possible to make observations is also very nearly a straight line, consequently, the final temperature distribution is the sum or difference of two linear distributions. In the case, therefore, of long intervals of time, the only evidence of a heat generating source in approaching an oil-bearing bed or other heat generating stratum is the large value of the gradient, or the small value of the reciprocal gradient. The only criterion that can be applied in this case is the comparison of gradients over the oil-bearing and the adjacent non-oil-bearing area With sufficient care in obtaining true rock temperatures, the validity or invalidity of the hypothesis should be capable of experimental confirmation. The effect of the heat generating source would be greatly magnified by erosion and steeply tilted beds.

I am greatly indebted to my assistant, Mr. H. Cecil Spicer, for the exceptional care and skill with which he has evaluated equations (9) and (13) for me. The results are summarized in Tables 1 and 2 and represented graphically in Figures 1 and 2.

GEOCHEMISTRY.—*Hydrogen-ion concentrations caused by the solution of silicate minerals.*[1] R. E. STEVENS, U. S. Geological Survey. (Communicated by R. C. WELLS.)

Hydrogen-ion concentration has been found to be an important factor in chemical equilibria of all kinds and its applications to biology, industrial chemistry, agriculture, physiology, bacteriology, and other fields, have been numerous and of great value[2] Its importance in geochemistry seems obvious but here the influence of hydrogen-ion concentrations has been little considered Recently W. R. G. Atkins[3] discussed its importance in this field and made a number of preliminary measurements on rocks and minerals. The hydrogen-ion concentration, or pH, largely determines the composition, and perhaps in many cases the crystal form, of minerals separating from solution. Alteration and corrosion are likewise affected by pH Inorganic reactions of all kinds are dependent on hydrogen-ion concentrations, examples of particular interest to geology are the relations in sulphide and carbonate equilibria The coagulation of colloidal material held in solution may also be caused by change in pH. Alkalinity or acidity, conveniently expressed in terms of pH, plays an important rôle in geochemical changes.

Waters percolating through the earth's crust become acid or alkaline owing to materials dissolved from the rocks, and if an abundance of a certain mineral is encountered equilibrium is established with this mineral, resulting in a definite equilibrium pH The effectiveness of each mineral would be dependent upon its ease of attack and abundance. The earth's crust is largely composed of silicate minerals and they would play a major part in maintenance of pH. F. W Clarke[4] says, "In the solid crust of the earth the silicates are by far the most important constituents. They form at least nine-tenths of the entire known mass and practically all the rocks except the sandstones, quartzites, and carbonates . . "

[1] Received August 17, 1932 Published by permission of the Director, U S Geological Survey A more extended paper dealing with this subject entitled "Studies on the alkalinity of some silicate minerals" will be published by the Geological Survey in Professional Paper 175

[2] See CLARK, W M, The determination of hydrogen ions, p 549, Williams and Wilkins, Baltimore 1928

[3] ATKINS, W R G *Some geochemical applications of measurements of hydrogen ion-concentration* Royal Dublin Soc Sci Proc **19**: 455–460 1930

[4] CLARKE, F W *The constitution of the natural silicates* U S Geol Survey Bull **588**: 5 1914

[5] See for example BOUYOUCOS, G J *Rate and extent of solubility of minerals and rocks under different treatments and conditions* Michigan Agr Exper Sta Tech Bull **50** 1921

That silicate minerals are attacked by water has been shown by field observations, and laboratory measurements[6] have revealed, in a general way, the extent and mechanism of the process. The mineral does not dissolve as a unit but by hydrolysis the alkali is taken into solution, leaving colloidal complexes of silica and alumina. The solutions, therefore show a high pH well on the alkaline side. Many of these minerals give much more alkaline solutions than do the carbonates, calcite and dolomite, although the importance of silicate minerals as sources of alkali has seldom been considered.

Because the discussion of hydrogen-ion concentrations involves principles not as yet broadly applied to geology, it seems wise to explain these briefly.

Water ionizes to a limited extent to give hydrogen and hydroxyl-ions thus:

$$HOH \rightleftharpoons H^{+} + OH^{-}$$

The extent of this reaction is slight but definite, and in pure water the number of hydrogen-ions would be the same as the number of hydroxyl-ions. When other substances in the water are present, however, there is usually more of one than the other of these ions, and use is then made of the fact, based on the law of mass action, that the product of the concentration of H^+ and OH^- is a constant, K_w. That is, $K_w = [H^+]\,[OH^-]$, where the bracketed quantities represent concentrations or activities. In pure water at 25°C. each ion, H^+ and OH^-, is present in a concentration of 1×10^{-7} gram ion per liter, so that $K_w = 1 \times 10^{-14}$. By adding acids the hydrogen-ion concentration is increased and the hydroxyl-ion concentration is decreased proportionately, maintaining the constancy of K_w. Strong acids are highly ionized, giving a large hydrogen-ion concentration, and nitric, sulphuric, and hydrochloric are among these. Weak acids, that are feebly ionized, are acetic and silicic. In like manner alkali increases the hydroxyl-ion concentration. Alkali and alkaline earth hydroxides are strong bases while ammonium hydroxide is a typical weak one.

The constancy of K_w makes it possible to express the concentration of both of these ions by merely stating the hydrogen-ion concentration. By expressing this in terms of pH, where $pH = \log \frac{1}{[H^+]}$, the fractional figures for hydrogen-ion concentrations are reduced to simple whole numbers. As the hydrogen-ion concentration of pure water is 1×10^{-7}, water or neutral solutions are at pH = 7, acid solutions are at pH less than 7, and alkaline solutions at pH greater than 7.

The hydrolysis of silicate minerals is simply illustrated by the reaction of water with wollastonite, $CaSiO_3$, shown in the following equation

$$CaSiO_3 + 2HOH \rightleftharpoons Ca(OH)_2 + H_2SiO_3$$

The silicic acid thus formed has but little effect on pH as it is weakly ionized and largely precipitated as SiO_2. Calcium hydroxide is a strong base, however, and it is almost completely ionized so that the dilute solution thus produced is strongly alkaline. Thus wollastonite was found to generate a high pH (11.17) when acted upon by water.

These measurements of mineral pH are a rough index of the amount of decomposition taking place and of the relative stability of the mineral in water. This follows also as a result of the law of mass action, for solutions containing a large concentration of hydroxyl-ions derived from relatively soluble minerals would inhibit further formation of that ion from the decomposition of more stable minerals and thus prevent their solution by hydrolysis.

Numerous methods were tried in preparing these solutions of silicates. Owing to the protective action of the colloids of silica and alumina formed, it was necessary to expose as large a surface as possible to water and to remove these protective films. Methods consisting of boiling and of churning the water containing finely ground minerals produced results that were considered too low and that could not be duplicated By grinding the mineral to a heavy suspension with a few drops of water in an agate mortar a maximum pH seemed to be reached after two minutes of grinding and check determinations showed close agreement Furthermore the mineral was so easily attacked in this way that an acid buffer solution could be quickly made alkaline, approaching closely the pH obtained when the mineral was ground in pure water

The colorimetric determinations were made by grinding the mineral for two minutes with one drop of water free from carbon dioxide and one drop of the appropriate indicator solution and comparing the color produced with that of a standard buffer solution of known pH, containing an equal quantity of the indicator. The quantity of mineral used had no measurable effect on the results, provided there was sufficient to give a heavy suspension. It was found that the color comparison could best be made by drawing the solution by capillarity into glass tubes of 1 mm. bore, keeping them upright for about a minute to allow mineral particles to settle as much as possible, and comparing

TABLE 1 RESULTS OF COLORIMETRIC DETERMINATIONS

Index No		Source	Composition	pH
1	Beryl	Connecticut	$Be_3Al_2Si_6O_{18}$	7 2
2	Genthite		$Ni_2Mg_2Si_3O_{10}$ $6H_2O$	7 8
3	Lepidolite		$KLi[Al(OH,F)_2]Al(SiO_3)_3$	8 4
4	Philipsite		$(K_2,Ca)Al_2Si_4O_{12}$ $4\frac{1}{2}$ H_2O	8 4
5	Stilbite	Mexico	$(Na_2,Ca)Al_2Si_6O_{16}$ $6H_2O$	8 6
6	Muscovite No 1	Utah	$H_2KAl_3(SiO_4)_3$, Sericite, fine powdery variety	7 8
7	Do No 3		Do	8 4
8	Do No 6		Do	8 5
9	Do No 2		Do	8 6
10	Do No 5		Do	8 7
11	Do No 4		Do	9 0
12	Calamine		$(ZnOH)_2$ SiO_3	8 8
13	Biotite	Philadelphia	$(H,K)_2(Mg,Fe)_2Al_2(SiO_4)_3$	9 0
14	Pollucite	Buckfield, Me	$H_2Cs_2Al_2(SiO_3)_5$	9 0
15	Anthophyllite	Montana	$(Mg,Fe)SiO_3$	9 0
16	Laumontite	Mordon, N S	$H_4CaAl_2Si_4O_{14}$ $2H_2O$	9 0
17	Orthoclase No 2	Maine	$KAlSi_3O_8$	8 8
18	Do No 1	Deadwood, S Dak	Do	9 2
19	Spodumene	Maine	$LiAl(SiO_3)_2$	9 2
20	Clinochlore	Chester County, Pa	$H_8Mg_5Al_2Si_3O_{18}$	9 2
21	Albite No 1		$NaAlSi_3O_8$	9 4
22	Do No 2		Do	9 7
23	Wyomingite (Leucite)	Wyoming	$KAl(SiO_3)_2$ (?)	9 4
24	Labradorite No 2		$NaAlSi_3O_8$ $3CaAl_2Si_2O_8$ (?)	9 4
25	Do No 1		Do	9 8
26	Margarite	Chester, Mass	$H_2CaAl_4Si_2O_{12}$	9 8
27	Natrolite		$Na_2Al_2Si_3O_{10}$ $2H_2O$	10 0
28	Epidote		$Ca_2(Al\ OH)(Al,\ Fe)_2(SiO_4)_3$ Varies	10 0
29	Actinolite	Roan Mtn , Tenn	$Ca(Mg,Fe)_3(SiO_3)_4$	10 0
30	Phlogopite		$H_2KMg_3Al(SiO_4)_3$ (?)	10 1
31	Diopside		$CaMg(SiO_3)_2$	10 1
32	Hornblende		$CaMg_3(SiO_3)_4$ with $Na_2Al_2(SiO_3)_4$ $+ Mg_2Al_4(SiO_6)_2$	10 2
33	Olivine	Willits, N C.	$(Mg,Fe)_2SiO_4$	10 2
34	Thulite		$HCa_2Al_3Si_3O_{13}$	10 2
35	Talc	Edwards, N Y	$H_2Mg_3(SiO_3)_4$	10 2

TABLE 1 RESULTS OF COLORIMETRIC DETERMINATIONS—*Concluded*

Index No			Source	Composition	pH
36	Pyroxene			$Ca(Mg,Fe)(SiO_3)_2$	10 2
37	Tremolite	No 1		$H_2Ca_2Mg_5(SiO_3)_8$	10 2
38	Do	No 2		Do	10 2
39	Pectolite			$HNaCa_2(SiO_3)_3$	10 4
40	Prehnite	No 3		$H_2Ca_2Al_2Si_3O_{12}$	10 2
41	Do	No 2	Michigan	Do	10 4
42	Do	No 1		Do	10 5
43	Apophyllite	No 1		$H_7KCa_4(SiO_3)_8 \cdot 4\frac{1}{2}\ H_2O$	10 4
44	Do	No 2		Do	10 4
45	Wollastonite			$CaSiO_3$	10 8
46	Glass	No 106[a]		SiO_2 75 48, Na_2O 15 26, CaO 9 26	11 2
47	Do	No 135[a]		SiO_2 78 40, Na_2O 16 17, CaO 0 21, MgO 5 22	11 4

[a] Analysis by F W GLAZE, U S Bureau of Standards

colors against a white background in indirect sunlight. For certainty, colors were duplicated several times and whenever possible checks were run using different indicators. The indicators and buffer solutions were selected from Clark's treatise, "The determination of hydrogen ions"

Colorimetric determinations on representative minerals are given in Table 1 The results are in good accord with field observations on the stability of these minerals and a relation to composition may be seen—the highly basic minerals giving a high pH Tests on different samples of the same mineral (see muscovite, orthoclase, albite, labradorite, tremolite, prehnite, and apophyllite) show a rather limited range of pH for the same mineral and, it is judged, differences are due to impurities, incipient alteration, possible varieties in the species, and similar variations inherent in natural products The alkalinity found for calamine in particular seems the result of impurities and not of its true composition. Nevertheless, the results as a whole show a remarkable gradation of pH between those minerals that are easily attacked by water and those that are relatively stable

The determinations on glass might be of interest to glass technologists. Results on two glasses of known composition are shown at the end of Table 1. Glasses tested having a higher content of alkali than these gave pH figures above 12 and could not be readily measured, while pyrex glass gave about pH = 8. This pyrex glass and the more

alkaline ones tested represent extremes of durability and show wide contrast in the test. The results for glass are of interest to mineralogists in that they show the effect of increased alkali content.

A more quantitative study of pH of a selected group of the minerals was made with the hydrogen electrode. Because the volume of solution prepared from the minerals was small a microelectrode was used. A simplified form of the one described by Bodine and Fink[6] was found to give good results. The hydrogen was generated electrolytically from caustic soda solution and passed over copper gauze at 500°C. before entering the electrode vessel. For the preliminary measurements a normal calomel half cell served as reference electrode but in most of the measurements the tenth normal electrode, recommended by Clark, was used instead. A saturated potassium chloride

TABLE 2. EFFECT OF CARBON DIOXIDE ON pH
MATERIAL USED, GLASS NO. 135

(TWO MINUTE GRINDINGS, NORMAL CALOMEL ELECTRODE USED)

1. GROUND IN AIR

Temperature	25°C	25°C	26°C	28°C
E. M. F.	0.9468	0.9555	0.9491	0.9490
pH	11.21	11.36	11.21	11.15
Average pH	11.23	Maximum deviation		0.13

2. GROUND IN NITROGEN FREE FROM CARBON DIOXIDE

Temperature	27°C	27°C	27°C	28°C	28°C
E. M. F.	0.9600	0.9675	0.9650	0.9680	0.9710
pH	11.47	11.49	11.46	11.47	11.51
Average pH	11.48	Maximum deviation		0.03	

bridge connected the two electrodes, a thermometer dipping into the potassium chloride showed the temperature at which measurements were made. The e.m.f. of the resulting cell was measured with a Leeds and Northrup, Type K, potentiometer and from this e.m.f. the pH of the solution was calculated.

It was expected that the results determined colorimetrically would be somewhat low, due to the effect of atmospheric carbon dioxide, and this was shown electrometrically by preparing the solutions in nitrogen free from carbon dioxide. A rubber diaphragm was stretched over the top of the mortar, fastened down with *passe-partout*, with small holes for the nitrogen inlet and for insertion of the pestle. The air was

[6] BODINE, J. H. and FINK, D. E. *A simple micro vessel with electrode for determining the hydrogen ion concentration of small amounts of fluid.* Jour. Gen. physiol. 7: 735. 1925.

Table 3 Time of Grinding Needed to Reach Equilibrium
(Normal calomel electrode used)

(a) One minute grinding

	Glass No 135		Spodumene		
Temperature	30°C	30°C	30°C	30°C	
E M F	0 9680	0 9685	0 8280	0 8330	
pH	11 40	11 40	9 08	9 15	
Average pH	11 40			9 11	

(b) Two minutes grinding

	Glass No 135		Spodumene		
Temperature	27°C	27°C	30°C	30°C	30°C
E M F	0 9660	0 9675	0 8410	0 8450	0 8430
pH	11 47	11 49	9 28	9 35	9 32
Average pH	11 48			9 32	

(c) Three minutes grinding

	Glass No 135		Spodumene		
Temperature	30°C	30°C	31°C	31°C	31°C
E M F	0 9745	0 9760	0 8470	0 8420	0 8430
pH	11 50	11 53	9 36	9 27	9 29
Average pH	11 51			9 31	

Table 4 Results of Electrometric Measurements

Index No	Mineral	Colorimetric pH	Electrometric pH	No of determinations	Maximum deviation from average	Temperature °C
	Calcite	9 0 (Atkins, 1930)	9 03	2	0 02	25
14	Pollucite	9 0	8 96	2	0 02	26
17	Orthoclase No 1	9 2	9 18	3	0 03	28
19	Spodumene	9 2	9 31	6	0 05	30–31
22	Albite No 2	9 6	9 84	2	0 04	28
27	Natrolite	10 0	10 05	2	0 03	28
37	Tremolite No 1	10 2	10 50	3	0 02	22
38	Do No 2	10 2	10 17*	3	0 06	24
44	Apophyllite No 2	10 4	10 79	3	0 02	26
45	Wollastonite	10 8	11 17	3	0 01	24
47	Glass No 135	11 4	11 49	7	0 04	27–30

* Probably too low Contained a trace of iron and 1 15 per cent manganese

swept out and the diaphragm inflated with nitrogen during grinding of the mineral. One of the more alkaline materials, glass No. 135, was selected for the test, that the effect might be more pronounced, and the results in Table 2 show that carbon dioxide lowered the pH figure by 0.25 pH and caused wide variations. Results where carbon dioxide was eliminated deviate from the average by only 0.03 pH unit. Therefore in all subsequent determinations carbon dioxide was eliminated.

The time of grinding could be extended to three minutes without the solution becoming so thick due to evaporation that measurements could not be made, and results in Table 3 show the effect of one, two, and three minute grindings. These results indicate a close approach to equilibrium in two minutes. All electrometric results were obtained after grinding the mineral in water for two minutes.

Minerals containing oxidizable materials, such as iron, chromium, and manganese, had to be avoided as they caused low electrometric readings

The results of the electrometric measurements on a number of minerals are given in Table 4. The degree of reproducibility seems remarkable, no determinations varying from the average by more than a few hundredths of a pH. The result for calcite, $CaCO_3$, checks closely the colorimetric determination by Atkins, whose work is referred to early in the text In general the electrometric and colorimetric results are in fair agreement, small deviations being accounted for largely by the action of carbon dioxide.

SUMMARY

By grinding silicates under water, solutions with characteristic and reproducible pH values have been obtained The colorimetric and electrometric results show that silicate minerals, when acted on by pure water, give highly alkaline solutions, and their importance as regulators of geochemical changes is indicated. The pH values obtained are a rough index of the weathering qualities of the mineral.

ZOOLOGY.—*A new amphipod of the genus* Leptocheirus *from Chesapeake Bay.*[1] CLARENCE R. SHOEMAKER, U. S. National Museum. (Communicated by W. L. SCHMITT.)

Recently while studying the amphipods of the genus *Leptocheirus* contained in the National Museum collection, I noted that specimens taken in the upper half of Chesapeake Bay by the U. S. Bureau of Fisheries during its biological survey in 1920 and 1921 belonged to a new and undescribed species, for which I now propose the name *Leptocheirus plumulosus.* The only other species of this genus known from the eastern coast of America, *Leptocheirus pinguis* (Stimpson), is very abundant off the coast of New England and has been recorded from the Gulf of St Lawrence south to the mouth of Chesapeake Bay (37°N , 74°W.), where a single specimen was taken by the *Albatross* in 1883.

L. plumulosus was taken at six localities ranging from the mouth of the Potomac River northward to the mouth of the Patapsco River, at depths between 9 and 43 fathoms

The specific name *plumulosus* is given in reference to the extremely feathery appearance of the second joint of the third, fourth, and fifth peraeopods.

Description, male —Head with lateral angle prominent and broadly rounding Eye oval, black and rather small Antenna 1 shorter than antenna 2, first joint stouter and longer than second which is stouter and longer than third, flagellum a little longer than peduncle and composed of about seventeen joints, accessory flagellum about equal in length to third peduncular joint and consisting of four or five joints the last of which is very small Antenna 2, fourth joint slightly longer than fifth, flagellum shorter than peduncle and consisting of about fourteen joints Mandible with secondary plate well developed, eight spines in spine-row, molar well developed and bearing a small accessory tooth at its base opposite the spine row, and also a plumose seta at its inner corner, palp with first, second, and third joints increasing slightly in length consecutively Maxilla 1, inner plate rather long and bearing a single terminal plumose seta, outer plate with eleven serrate spine teeth, palp bearing five apical spines and several setae Maxilla 2 not differing from that of other species of the genus Maxillipeds about as figured by Sars for *L pilosus*[2] Lower lip with inner and outer lobes well developed, mandibular processes rather small Side-plate 1 not produced forward, margins slightly converging toward the evenly rounding lower border which is beset with a row of fine plumose setae Gnathopod 1 robust and strong, fifth and sixth joints about equal in length, sixth joint widening distally, palm slightly oblique with a central concavity, defining angle evenly rounding without defining spine, seventh joint not overlapping palm and with inside edge bearing a row of fine spinules The first, second, third,

[1] Published by permission of the Secretary of the Smithsonian Institution Received August 30, 1932

[2] G O SARS *Crustacea of Norway*, 1· *pl* 197, *fig* mp

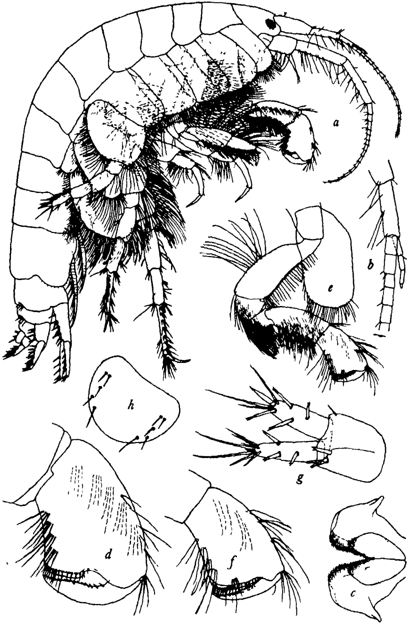

FIG 1.—*Leptocheirus plumulosus*, new species Male, *a*, Entire animal *b*, Accessory flagellum *c*, Lower lip *d*, Sixth and seventh joints of gnathopod 1 *e*, Gnathopod 1 of female *f*, Sixth and seventh joints of gnathopod 1 of female *g*, Uropod 3, right *h*, Telson

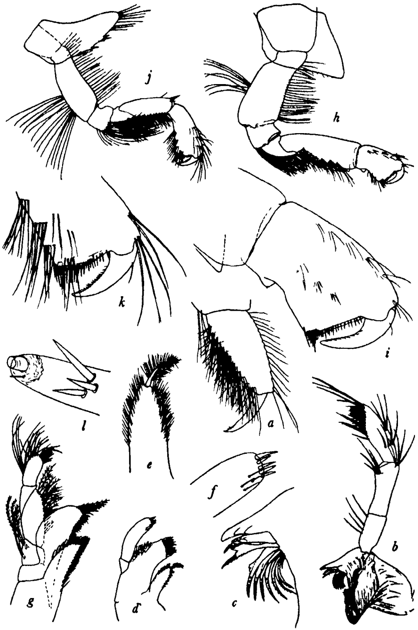

Fig 2.—*Leptocheirus plumulosus*, new species Male, *a*, End of gnathopod 2 *b*, Mandible *c*, Cutting plates and spine-row of mandible *d*, Maxilla 1 *e*, Inner plate of maxilla 1 *f*, End of palp of maxilla 1 *g*, Maxilliped *h*, *i*, Gnathopod 1 of *L pinguis*, male *j*, *k*, Gnathopod 1 of *L pinguis*, female *l*, Outer ramus of uropod 3 of *L pinguis* showing rudimentary second joint

and fourth joints of gnathopod 1 are densely beset with groups, bundles, and rows of plumose setae which give them a brush-like appearance, and the sixth joint bears five or six groups of spines on hind margin Side-plate 2 slightly expanded distally. Gnathopod 2 about as figured by Sars for *L pilosus*, and having the same armature of plumose setae Peraeopods 1 and 2 about equal in size and shape and are proportionally as shown in the figure of the entire animal Side-plate 5 with front lobe as deep as side-plate 4. Peraeopod 3 with the expanded rear margin of second joint produced upward and both front and rear margins bearing a dense row of long plumose setae Peraeopod 4 with rear margin of second joint less produced upward than 4, front and rear margins edged with long plumose setae Peraeopod 5 with rear margin scarcely at all produced upward, and somewhat angular, front and rear margins densely edged with long plumose setae Pleon segments 1 and 2 densely clothed on their lower parts with long, curved, plumose setae Pleon segment 3 with lateral margin and lower corner evenly rounding and bearing a few fine spinules Pleon segments 4 and 5 without dorsal teeth but each bearing on either side a row of four spinules on an oblique offset of the lateral margin near the dorsal surface Uropods 1 and 2 reaching back about the same distance which perhaps is slightly farther than uropod 3 The spine-like apical process of uropods 1 and 2 reaches nearly to the middle of the outer ramus Uropod 3 with rami short and about equal in length to the peduncle, the outer ramus bears a terminal group of spines of various lengths, but no rudimentary second joint could be observed such as is present in *L pinguis* In uropods 1 and 2 the outer ramus is the shorter, but in uropod 3 it is slightly the longer Telson broader than long, almost evenly rounding posteriorly and bearing about five spinules near either lateral margin

Length --Male about 11 mm , female somewhat less

Type locality --*Fish Hawk* station 8963, Chesapeake Bay, Md : Bloody Pt 99°, Thomas Pt Light 15° March 28, 1921, 9 fathoms (Cat No 66075 U S N M)

In the female the palm of gnathopod 1 is evenly convex and almost transverse with smoothly rounding defining angle which is preceded by a rather small spine-tooth In all other characters the female bears a close resemblance to the male

In *L plumulosus* antenna 1 is shorter than antenna 2, a character which does not agree with Stebbing's definition of the genus Neither is there a second rudimentary joint to the outer ramus of uropod 3,[3] but in all other characters there is such a close agreement with *Leptocheirus* that I believe it best to include it in that genus

In *L pinguis* the first gnathopod of the male has the palm oblique and about straight with a spine-tooth at the narrowly rounding defining angle; the seventh joint being stout, much curved and the apex only closing against the defining angle of the palm Gnathopod 1 of the female of *L pinguis* has the sixth joint much as in the present species except that it is proportionally longer and narrower

[3] E W SEXTON *On the Amphipod genus* Leptocheirus Proc Zool Soc London 2: 562 1911

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY

492ND MEETING

The 492nd meeting was held at the Cosmos Club, October 12, 1932, President F. E. MATTHES presiding.

Program P B KING *General structural features of the Cordilleran Province.* —This paper summarizes part of the results of a compilation made for a guide-book of the International Geological Congress on the structural features of the United States. The Cordilleran province, in a structural sense, applies to the area of folded and faulted rocks which lies along the western side of the central stable region of North America The most active deformation in the province was in later Mesozoic and early Cenozoic time, but there was a complex pre-deformation and post-deformation history. The local geologic history and the effects produced by the deformation are quite different in different parts of the province, so that it is divisible into a number of distinct subdivisions

(A) Along the west coast is a chain of Coast Ranges, which is a comparatively young feature.

(B) East of the Coast Ranges is a zone of structural features which is typically developed in the Sierra Nevada. It is characterized by batholiths of large size, and by a thick metamorphosed stratigraphic succession composed predominantly of clastic and volcanic rocks and ranging in age from early Paleozoic to Jurassic This zone was intensely deformed in middle Mesozoic time, and was made rigid enough to transmit a thrust from the west to the next zone to the east

(C) East of the zone of structural features of Sierra Nevada type is a belt of strong folding and overthrusting, which extends from the northern Rocky Mountains through the Great Basin into the Sierra Madre Oriental of Mexico The belt is characterized by great thicknesses of sedimentary rocks, which are of different ages in different places. In the northern Rockies the thickest sedimentary rocks are of Algonkian age, in the central Great Basin of early Paleozoic age, in the eastern Great Basin of later Paleozoic age, and in the Sierra Madre of Mesozoic age The belt is characterized by great overthrust faults which have moved from west to east, which are of early Tertiary age along the eastern margin of the belt The belt directly faces the Great Plains near the Canadian boundary, and the Gulf Coastal Plain in Mexico. Between these points, plateaus and outer ranges lie in front

(D) About midway along the length of the Rocky Mountain belt is the Colorado Plateau, a broad positive area which has never been greatly deformed It has behaved as a rigid area during the Cordilleran deformation, and has transmitted the thrust from the west to the Rocky Mountains of Colorado and Wyoming which lie northeast of it

(E) The ranges northeast of the Colorado Plateau are for the most part broad open folds which reveal pre-Cambrian crystalline rocks on their crests In Colorado, however, the relations are more complex. Here there is much more close folding and overthrusting This is partly because these ranges have been reelevated on the site of old Paleozoic chains, and because of the exceptional thicknesses of Paleozoic intermontane deposits laid down between the earlier ranges

Study of the Cordilleran province suggests that the motivating forces were compressional forces which originated near the Pacific border, and whose existence was long continued Sedimentation has been intimately related to the compressional movements, but it was an effect rather than a cause The character of the sedimentation has strongly influenced the distribution and character of the later structural features The diverse units of the Cordilleran province appear to have resulted from the interaction of regions of different degrees of competency, under the influence of the thrust from the west (*Author's abstract*)

Discussed by Messrs SPENCER, C P ROSS, GILLULY, RESSER, HEWETT, and RUBEY

K E LOHMAN *Diatoms and their significance in geology* The value of diatoms as stratigraphic and ecologic indicators has been greatly neglected by geologists in the past Diatoms, having siliceous tests, are well preserved under most conditions and their abundance, both as to numbers of species and individuals, makes possible a reasonable understanding of the environmental conditions obtaining during their deposition Living diatoms occur in many types of habitat, marine, brackish, saline, and fresh water bodies containing unique assemblages varying in quantity from a few hundred cells per liter to more than twelve million They occur nearly pure in diatomites, less so in diatomaceous shales, clays, mudstones, siltstones, limestones, and calcareous concretions

Diatoms occur in rocks of all geologic ages from Jurassic to Recent, older occurrences being reported but not sufficiently authenticated Excellent diatom floras have been obtained from marine Cretaceous, Eocene, Oligocene (?), Miocene, and Pliocene beds in California as well as from non-marine Miocene, Pliocene, and Pleistocene beds in Oregon and Nevada. To cite one example of their value in correlation The Temblor formation of California, which has been called Middle Miocene on the evidence of molluscs, contains the same short-ranged species of diatoms as the Calvert Formation of Maryland and Virginia, also called Middle Miocene on molluscan evidence (*Author's abstract*)

Discussed by Messrs GOLDMAN, COOKE, CAPPS, R C WELLS, STEVENSON, G R MANSFIELD, and LADD

BOTANICAL SOCIETY

ANNUAL OUTING

A special informal field meeting and picnic was held at the Montgomery Sycamore Island Club on the afternoon of June 6, 1931, attendance about 50 Through the courtesy of the Club the grounds were reserved for the Society

Members and their families botanized, played games, bathed in the Potomac and otherwise amused themselves About 5 P M , ice cream was served by the Society, individuals having furnished their own lunches

235TH MEETING

The 235th regular meeting was held in the Assembly Hall of the Cosmos Club on October 6, 1931 President N E STEVENS presided, 51 members and guests were present

The following were elected to membership. MISS MARY A BRADLEY, DR J. A. FARIS, MISS FALBA L. JOHNSON, and DR. EARL S JOHNSTON

Reports of summer meetings of interest to botanists

MISS MARY BRYAN —The Appalachian Trail Conference in the Great Smoky Mountains

C. L. SHEAR.—The fungous foray at Ithaca

E. H. TOOLE —The Sixth International Seed-testing Congress in the Netherlands.

N. E STEVENS —The Bartram Memorial Meeting commemorating the 200th anniversary of the first Botanical Garden

M. C. MERRILL —Special field meeting of the Botanical Society of Washington

Brief Notes and Reviews Doctor WAITE referred to his previous remarks on lily pods and exhibited pods of *Lilium regale* illustrating the special organs for keeping the seed from scattering too soon and for keeping the pod erect.

Program· Wild flowers of the Yosemite Park, a two reel film by A C. PILLSBURY, shown by P. L RICKER

SPECIAL MEETING

A special meeting was held in Room 43 of the New National Museum on October 23, 1931 Attendance, about 60, including guests from the Wild Flower Preservation and from the Biological Societies

Program· Dr. JAKOB E. LANGE of Denmark —*Comparative studies of European and American species of mushrooms and toadstools.* The speaker had noticed on a previous trip to the United States that many of the species here were the same as those found in Europe and that some of the species had been named by American investigators on small differences. The fact that it is impossible to make good herbarium specimens of mushrooms and that photographs are inadequate for identification has lead to confusion between American and European mycologists Printed descriptions of species as well as portraits painted by an artist are of no value for classification However, colored drawings done by a mycologist are very useful, identification being easily made provided enough species have been illustrated. So far only a few hundred have been drawn by the author. The need for more intensive work is plainly evident Attention was called to the wonderful opportunity which America has in such a program Being a large country, under one government and with a common language makes it possible for America to outstrip Europe in the study of the fleshy fungi Colored drawings of a considerable number of species of mushrooms were exhibited

NATHAN R SMITH, *Recording Secretary*

236TH MEETING

The 236th regular meeting was held in the Assembly Hall of the Cosmos Club on November 3, 1931 President N. E STEVENS presided, about 80 members and guests were present

Brief notes and reviews: H B HUMPHREY called attention to a Plant Physiology by E C. MILLER, recently published by McGraw-Hill Book Company. N A COBB spoke of the JOURNAL of the WASHINGTON ACADEMY as a very prompt and efficient means of publication for short papers and asked for suggestions from the Society for improvement of the JOURNAL. The motion was made and carried that a committee be appointed to make recommendations and to confer with the editor of the JOURNAL and with Dr. HUMPHREY, the representative of the Society to the Academy M. B WAITE remarked on the unusual growth of annual weeds and the late maturing of peaches and other plants. He attributed these to an abnormal amount of nitrates in the soil due to the recent drought

Program: P. H DORSETT—*Open air winter forcing of strawberries in Japan* (illustrated) This unique horticultural practice has been developed locally in Japan during the past twenty-five years with an industry amounting to $35,000 in 1929 and 1930. Stone-faced beds are built at an angle of 45° on terraces up the southern slopes of Mount Kunozan, a day's ride west of Tokio This method produces berries five times earlier and plants four to five times more prolific than can be produced by other methods

P. H DORSETT: *Interesting features of Chinese "Ching Ma"*—*Abutilon Theophrasti* is a widely distributed weed in this country but in China it is grown for its fiber and stems The speaker exhibited samples of rope, fire-crackers and charcoal made from this plant These products are being investigated in the United States as possible sources of a new industry

CHARLOTTE ELLIOTT, *Corresponding Secretary*

237TH MEETING

The 237th regular meeting was held in the Assembly Hall of the Cosmos Club on December 1, 1931 President N E STEVENS presided, about 105 members and guests were present

The following were elected to membership WALTER A DAVIDSON, OSCAR J DOWD, F W OLDENBURG, and KENNETH B RAPER

Program N E STEVENS, Retiring President of the Society—*The fad as a factor in botanical publications* This address has been published in full in Science

Brief Notes and Reviews: Doctor WEISS called attention to the destruction of elms on East Capitol Street and the Ginkgo and other groups in the grounds of the Department of Agriculture He proposed the following resolution

WHEREAS The National Capitol Park and Planning Commission, in the furtherance of its efforts to transform the natural beauty of the Department of Agriculture grounds—a beauty which is derived from the varied contour and the plantings of stately and historic trees—into something of the general topographic and vegetational features of an Illinois prairie to be adorned with four magnificent concrete roadways, has caused the destruction of the famed Ginkgo Avenue in the Agricultural Department grounds,

BE IT RESOLVED, by the Botanical Society of Washington, that cognizance be taken of this act of destruction, and that the regret of the members at the loss of this notable planting of Ginkgo trees and other groups of trees in the Agricultural grounds, be recorded on the minutes of this, the 237th meeting of the Society, and

BE IT FURTHER RESOLVED, that we hereby deprecate the failure of the Park and Planning Commission to realize the possibilities of civic beautification by preserving, so far as possible, natural objects and conditions.

Moved and seconded, that the resolution be adopted. It was discussed by M. B. WAITE and J B S NORTON and then carried

The meeting then adjourned so that the annual meeting and election of officers might be held

ANNUAL MEETING

The 31st annual meeting was held immediately following the adjournment of the 237th regular meeting on December 1, 1931

The Recording Secretary reported that during the past year, eight regular meetings, one buffet dinner with entertainment, one field meeting and picnic and one special meeting were held The attendance at the regular meetings

were: January, 102, February, 150, March, 200, April, 41, May, 96, October, 51, November, 80, December, 105 Average, 103 Twenty-four new members were elected, two absent members replaced on mailing lists, ten have resigned or have been placed on the absent list, three deaths have occurred, leaving an active membership list of 200.

The Corresponding Secretary read the following list of members who had died during the past three years

DR P A YODER 1867–July 18, 1929
Biographical sketch in Journ Wash Acad Sci **19**: 394 1929

DR W A ORTON 1877–January 7, 1930
Biographical sketch in Phytopathology **21**: 1–11 1931

DR E G ARZBERGER 1877–January 29, 1930
Biographical sketch in Phytopathology **21**: 576 1931

DR F J PRITCHARD 1874–January 13, 1931
Biographical sketch has been submitted for publication in Phytopathology

DR W J SPILLMAN 1863–July 11, 1931
Biographical sketch in U S Dept Agric Official Record **10**: 218. 1931

DR R A OAKLEY 1880–August 6, 1931
Biographical sketch in Science **74**: 195 1931

The report of the Treasurer was read The President appointed JOHN STEVENSON and W A MCCUBBIN as an auditing committee

The following officers were elected by ballot

President—DR. J B S NORTON
Vice President—DR CHARLES BROOKS
Recording Secretary—NATHAN R SMITH
Corresponding Secretary—DR CHARLOTTE ELLIOTT
Treasurer—EDITH CASH
Vice President of the Washington Academy of Sciences—DR H B HUMPHREY

238TH MEETING

The 238th regular meeting was held in the Assembly Hall of the Cosmos Club on January 5, 1932 President J B S NORTON presided Attendance about 110

The following were elected to membership: A W SKUDERNA, DR HOWARD W JOHNSON, DR RONALD BAMFORD, and DR GLENN A. GREATHOUSE

Brief Notes and Reviews DR WAITE exhibited specimens of Bermuda grass which is still green, due to the mildness of the winter He also exhibited branches cut from peach trees in this locality which showed fewer buds than in normal years Reports from Illinois, Indiana and California, also indicate that fewer buds are laid down this year than normal This may in part be due to the heavy crop last year DR CHARLES SWINGLE exhibited a species of *Bryophyllum* brought from Madagascar which is still alive outdoors, while specimens of this plant in California had been killed by the cold Five minute reports on the New Orleans meetings of the American Association for the Advancement of Science were given by DR N E STEVENS and OSCAR J DOWD

Program: LEE M. HUTCHINS.—*Phony Peach Some new departures in a virus disease.* (illustrated) Peach trees affected with this disease have a darker green color, are more dense and produce much smaller fruit The disease has been slowly spreading and has resulted in great losses in certain localities Experiments, involving thousands of grafts of roots and scions, to determine the cause of this disease were discussed. The fact was finally established that this virus disease is localized in the roots, the trunks and limbs being free of the infective agent. The means by which this disease is spread has not yet been determined Discussed by DR WAITE, DR KELLERMAN, DR TAYLOR, and others.

239TH MEETING

The 239th regular meeting was held on February 2, 1932, in the Assembly Hall of the Cosmos Club, attendance 83

DR M. C GOLDSWORTHY was elected to membership

Brief notes and reviews DR J S COOLEY exhibited a culture of *Xylaria mali* which showed phototropium DR HITCHCOCK reported on the examination of material suspended in the air as caught by air-planes One half of the fifty specimens contained seeds of Vasey grass whereas the light fluffy seeds were not found DR NORTON called attention to a host index of rusts and also to a list of forty-seven species of plants found blooming in December and January of this winter DR WAITE called attention to a publication in the Geographical Review dealing with the climates of North America in which many interesting points are brought out including a map of the climates DR THONE exhibited the new address book of botanists, a textbook of botany by Coulter, Barnes, and Cowles and a German treatise, Arbeiten über Kalidungung

Program· M C GOLDSWORTHY —*The effect of smelter smoke upon plants* (illustrated) G G HEDGCOCK *Crop plants, Forest vegetation* The data presented by both speakers will be published later

SPECIAL MEETING

A special meeting was held on February 16, 1932, in the Auditorium of the Interior Department, attendance about 160

Program E V ABBOTT —*Travels in Peru* —The talk was illustrated by lantern slides showing the agriculture, Indian life and scenic beauties of the country

Following the talk, several members asked questions of the speaker and DR. HITCHCOCK spoke briefly of his travels through the same region.

NATHAN R SMITH, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

NOTES

Public Health Service officers speak—The meeting of the New York Electrical Society on the evening of November 16 was devoted mainly to the U S Public Health Service Among the speakers were Dr R E DYER, Surgeon General HUGH S CUMMING, and Prof CARL VOEGTLIN Dr. DYER's appearance was his first since he contracted an attack of endemic typhus fever in the course of his studies of the etiology of that disease He spoke, appropriately, on the history of the fight against typhus in this country Surgeon General CUMMING devoted most of his address to a description of the new U S National Institute of Health He also outlined the combination of laboratory and field work involved in the attack on certain diseases, such as malaria Prof VOEGTLIN presented the results of his chemical investigation into the physiology of cancer tissue In an atmosphere of nitrogen, the albumen of both cancerous and normal cells breaks down, he said, while in the presence of oxygen it is restored Low concentrations of copper and lead inhibit the growth of cancer tissue, no other metals in the same concentrations affect it

More Eskimo archaeology—Two expeditions of the U S National Museum which have been investigating Eskimo archaeology during the past season have returned, both reporting gratifying results Dr. ALEŠ HRDLIČKA brought back much skeletal material and many artifacts, some of them of real beauty, considering the obdurate materials in which the ancient craftsmen had to work These objects give further evidence of the relatively high culture level of the early immigrants that crossed the strait from Asia

Mr JAMES A FORD, who spent last winter in the Alaskan Arctic, solved the riddle of the ancient mode of Eskimo burial It has long been thought that the ancient Eskimos at Point Barrow buried their dead either in actual houses or in house-like sepulchres Mr FORD discovered that they did neither They took the top off a natural knoll, laid down a plank floor on which they placed their dead, and then replaced the earth, giving the finished mound a deceptively house-like appearance

Extra vertebrae in Eskimos—Supernumerary vertebrae are not uncommon in man, all races show them But the percentage among Eskimos seems to be high Among some two hundred Eskimo skeletons examined by Dr T D. STEWART at the U S. National Museum, about twelve per cent had 25 presacral vertebrae, instead of the normal 24 The highest previously reported percentage was 7, among Japanese, Europeans have supernumerary vertebrae in from 3 to 6 per cent of known cases

Burbank still getting plant patents—LUTHER BURBANK, though dead, is the holder of more patents under the new plant patent law than any living plant breeder Recently his seventh plant patent, on a variety of cherry, was granted, through his executrix, ELIZABETH WATERS BURBANK

Since the passage of the plant patent law a little more than two years ago, 43 patents on plants have been granted

Corn borer spread retarded.—Due to weather conditions unfavorable for the flight of adult moths, the spread of the European corn borer was retarded during the past season, the U. S. Department of Agriculture has announced The corn borer area now includes territory as far west as Wisconsin, and extends from the corn-growing provinces of Canada on the north to Kentucky, Virginia, and Maryland on the South

An ancient "modern" hawk—At the meeting of the National Academy of Sciences in Ann Arbor, on November 15, Dr ALEXANDER WETMORE of the U S National Museum, with Prof ERMINE C CASE of the University of Michigan, presented a paper on the skull of a fossil bird from the Badlands of South Dakota. Although of Oligocene age, the specimen undoubtedly belongs to the living genus *Buteo*

National Museum has "Uralt" mammal—A fragmentary skull of a small mammal in the U. S. National Museum has been identified as belonging to the Paleocene genus *Anisonchus* by Dr GEORGE GAYLORD SIMPSON of the American Museum of Natural History, and is assigned by him to a new species, *A fortunatus*

The new species is happily named, for its discovery was apparently a matter of sheer luck A hollow tool, lowered into a deep oil well in Louisiana, accidentally gouged out a core from the wall, and in this material the broken fossil was found Thought at first to be Cretaceous in age, its correct date and identity were determined upon more careful examination

New National Reservations proposed—Director HORACE M ALBRIGHT, of the U. S National Park Service, during his annual summer tour of inspection made a personal investigation of three proposed new national reservations which would be administered by the Park Service One lies in the Badlands of North Dakota, identified with the name and hunting activities of the late THEODORE ROOSEVELT A bill sponsored by Senator NYE and Representative SINCLAIR proposes to make this area into a national park The second proposed new national park would be in the Badlands of South Dakota, along the main road to the Black Hills This was formerly a great game area, and is still notable for its great wealth of fossils A third park project is in Wyoming and Nebraska, including Guernsey Lake and historic Fort Laramie. Besides the proposed new national parks, a thorough discussion of the mooted question of the acquisition of lands in the Jackson Hole country, to be offered to the government for park purposes, may be expected during the coming legislative season.

Hybrid Oysters—Japanese oysters and the oysters of the American Atlantic seaboard are sexually quite compatible, Dr P. S GALTSOFF and R O SMITH, of the U S Bureau of Fisheries, have announced in *Science* Sperm from the males of either species will induce the females of the other species to discharge their eggs, they found in a series of experiments Furthermore, viable hybrid oysters are formed, which in the young stages show no higher mortality rate than do "pure-bred" young oysters of either species

This biological situation does not promise well for the oyster industry of the Atlantic seaboard, fisheries men point out There is a desire among some of the commercial oystermen to plant the Japanese oyster in Atlantic coast oyster beds The Japanese species is said to be faster-growing than the

American, but in the opinion of many is of inferior flavor. Champions of the native oyster fear that natural hybridization will ruin the American species They would like to find legal means to stop the planting of the Japanese oyster, but at present there is no legislation, either state or federal, to help them

Posters for conservation —A wild flower poster contest, open to school children in the District of Columbia, as well as to adults, is announced by the Wild Flower Preservation Society. Its purpose is to develop interest in the fate of endangered native species, and at the same time obtain material for use in a campaign of public education. Winners in the District contest, which closes April 15, 1933, will be eligible for a national contest. Particulars may be obtained by addressing The Wild Flower Preservation Society, 3740 Oliver St, Washington, D C

NEWS BRIEFS

Soil scientists from all parts of the United States were in Washington for the meetings of the American Soil Survey Association, November 15 to 17, and the American Society of Agronomy, November 17 and 18

The Washington section of the Society of American Foresters held its second fall meeting at the Cosmos Club on the evening of November 17. The meeting was addressed by BURT P KIRKLAND, of the U S Forest Service.

The National Park Service reports the presence in Yellowstone National Park of 58 trumpeter swans during the past season This bird, though still near extinction, is apparently on the increase in the park area GEORGE WRIGHT, of the National Park Service, is now in Yellowstone studying the winter status of these swans, and also observing the elk on their winter feeding grounds.

The Geological Society of Washington held its 494th meeting at the Cosmos Club on November 9 Dr T A JAGGAR, Director of the Hawaiian Volcano Observatory, spoke on *Recent investigations on Pacific volcanology*, Dr C S Ross on *Genesis of titanium deposits of Nelson County, Virginia*, and Mr W. H. MONROE on *Topography and physiography from aerial photographs*

The Pan-American Union announces that the White House Conference on Child Welfare held here in 1931 has had a great deal of influence in Latin America Child Welfare Weeks have been recently held in Venezuela, and in Colombia one was planned, but circumstances compelled its postponement In Argentina, Dr ARÁOZ ALFARO, recognized as dean of his profession, gave a public lecture on the results of the Conference and their possible application to Argentina

The Washington Chapter of the Pan-American Medical Association held its first winter meeting at the Nicaraguan Legation on November 21

At the School of Medicine of the George Washington University, a new society named in honor of THEOLBALD SMITH, WALTER REED and FREDERICK F. RUSSELL, all former professors of bacteriology in the institution, has been formed. The Smith-Reed-Russell Society is sponsoring a series of lectures during the present academic year

PERSONAL ITEMS

At the meeting of the National Academy of Sciences in Ann Arbor, on November 14, Dr. WALTER HOUGH presented a biographical memoir of the late Dr JESSE WALTER FEWKES

Dr W W COBLENTZ was a delegate to the International Light Congress at Copenhagen He presented a paper on a new standard for ultraviolet light

Dr J A FLEMING has been elected an honorary and corresponding member of the State Russian Geographical Society

FRANK T DAVIES, formerly of the Byrd Antarctic Expedition, and now on furlough at the request of the Meteorological Service of Canada, from the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, is in charge of the Polar Year station at Chesterfield Inlet This station is the nearest point to the North Magnetic Pole at which continuous records will be taken during the Polar Year

W J. ROONEY, of the Department of Terrestrial Magnetism, who was temporarily assigned to the U. S Coast and Geodetic Polar Year Station at College, Alaska, to assist in the installation of the atmospheric-electric and earth-current equipment, has completed his work and returned to Washington K L SHERMAN will be in charge of the work during the Polar Year

Dr LUIS M DE BAYLE, Chargé d'Affaires of Nicaragua in Washington, has been made an honorary member of the Association of Military Surgeons of the United States His father, a noted surgeon of Nicaragua, was also made an honorary member of the Association of Military Surgeons a few years ago

Dr L O HOWARD has returned from his residence in Paris, to resume his research and writing work here He has a new book in press, which will be published in the near future.

Obituary

Captain ROBERT LEE FARIS, Assistant Director of the U S Coast and Geodetic Survey, died suddenly at his home on October 5, 1932. He was born at Caruthersville, Missouri, on January 13, 1868 Graduating from the University of Missouri in 1890, with the degree of Civil Engineer, he served for a year as an assistant engineer with the Corps of Engineers, U S Army

He entered the service of the U S Coast and Geodetic Survey in 1891 He was engaged upon the various field operations of the Bureau until, in 1906, he became inspector of magnetic work and Chief of the Division of Terrestrial Magnetism, a position he held until 1914, when he became Assistant Inspector of Hydrography and Topography The following year he was appointed Assistant Director He wrote widely, contributing many articles and publications relating chiefly to magnetism

Captain FARIS was appointed a member of the Mississippi River Commission in 1919, and served until his death He was a fellow of the American Association for the Advancement of Science, a member of the Committee on Navigation and Nautical Instruments of the National Research Council, the Federal Board of Surveys and Maps, the Washington Academy of Sciences, the Philosophical Society of Washington (President 1921), the Washington Society of Engineers (President 1921), the American Society of Civil Engineers, the American Astronomical Society, the American Geophysical Union, the Society of American Military Engineers, the Geological Society of Washington, and of the International Association of Navigation Congresses.

He served as Treasurer of the Washington Academy of Sciences from 1918 to 1930

BARTON WARREN EVERMANN, director of the Museum of the California Academy of Sciences and of the Steinhart Aquarium, San Francisco, died on September 27, 1932. He was born in Monroe County, Iowa, on October 24, 1853 He matriculated at Butler University, Ind in 1877. Here he met Dr David Starr Jordan in whose classes he began the study of natural history From that day until Doctor Jordan's death in 1931 the two men remained associated in one way or another in their scientific work Together they made many explorations, collected fish in nearly every state in the Union, and as co-authors they wrote many books and papers The most important of these is the monumental work in four volumes, *The Fishes of North and Middle America*, published by the U. S National Museum as Bulletin No. 47 (1896–1900) Another important joint work of Jordan and Evermann is their semipopular book, *American Food and Game Fishes* (1902) which has gone through several editions

In 1891, Doctor Evermann entered Indiana University, where Doctor Jordan was then professor of biology Here he received the B S degree in 1886, the A M in 1888, the Ph D in 1891, and the honorary degree of LL D in 1928

In 1891 he joined the staff of the Bureau of Fisheries and in 1902 became Chief of the Division of Statistics and Methods In 1903 he was appointed Chief of the Division of Scientific Inquiry, and in 1911, Chief of the Alaska Division He was also curator of fishes in the National Museum from 1905–1914 In 1914 he resigned from the Bureau of Fisheries to become director of the Museum of the California Academy of Sciences, a position he held at the time of his death

Doctor Evermann served on the U S Fur Seal Commission (1892), on the International Fisheries Commission (1908–09), on the Board of Education, Washington, D. C. (1906–10), and lectured at Stanford, Yale, and Cornell He was a member of many scientific societies and was the author of 387 publications

INDEX TO VOLUME 22

An * denotes the abstract of a paper before the ACADEMY or an affiliated society

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

AUTHOR INDEX

SUBJECT INDEX